

Geotechnologies and Artificial Intelligence as a Tool of Riparian Forest Management

Elidinaldo da Silva Leite, Dr. Ricardo José Rocha Amorim

Program of Human Ecology and Social-Environmental Management - PPGEcoH, University of the State of Bahia – UNEB, BRAZIL

Received: 15 May 2021;

Received in revised form:

07 Jun 2021;

Accepted: 18 Jun 2021;

Available online: 29 Jun 2021

©2021 The Author(s). Published by AI
Publication. This is an open access article
under the CC BY license

(<https://creativecommons.org/licenses/by/4.0/>).

Keywords — *Geotechnology; Remote Sensing
(RS); Artificial Intelligence (AI).*

Abstract — *Geotechnologies are important tools for natural resource management in the face of urgent questions and answers demanded by society. They are able to offer a range of mechanisms that, through technique and science, enable the understanding of the starting points through location, dimension, acquisition and processing. For this purpose, the use of Artificial Intelligence (AI) techniques has helped in the manipulation of data ascending from the extensive volume of information generated, as well as the improvement of computational systems. The objective of this paper was to verify the relationship between geotechnologies with emphasis on Remote Sensing (RS) in the management of natural resources, such as riparian forest Permanent Preservation Areas (PPAs) and the use of Artificial Intelligence (AI). For this, a quali-quantitative and descriptive work hereby presented has been considered in the research: Science Direct, Resergate, Scielo and Google Scholar, with emphasis on articles published in journals in both English and Portuguese languages between 2018 and 2020, and explored in the first half of 2021. The summation of the two databases enabled the following results: 07 articles (2018), 15 articles (2019), 32 articles (2020), dissertations (50), articles in proceedings (01), chapters (02), e-books (07), articles in symposia (03), pages without access (13), theses (25), monographs (20), totaling 162 works. The data also revealed little publication on the theme, especially in Portuguese, of articles related to the use of artificial intelligence. However, the use of AI has presented itself as an important tool in research allied to remote sensing and GIS software. Therefore, it was not possible to verify the existence of studies of riparian forest APP using artificial intelligence, indicating a relevant research gap in this area. Thus, it is suggested in future researches the increase of applications of artificial intelligence directed to the study of riparian forest APP associated with geotechnologies.*

I. INTRODUCTION

Technological advances have enabled the progress of science and research through the interrelation of data. Great impetus in computing systems, both hardware and software, has eased this evolution in the analysis, manipulation, and extraction of data, e.g. geotechnologies

(ALVES; MARTINS; SCOPEL, 2020; MEDEIROS; ALBUQUERQUE, 2019; LEITE; RODRIGUES; LEITE, 2018). Moreover, the use of artificial intelligence has expedited the manipulation of information (OLIVEIRA; CÂMARA, 2019), as well as machine learning, deep learning, and neural networks, in which these processes are differentiated (DIKSHIT; PRADHAN; ALAMRI, 2020).

Among the geotechnologies, Remote Sensing (RS), Geographic Information System (GIS) and the Global Navigation Satellite System (GNSS), with emphasis on the Global Positioning System (GPS), are worth mentioning. These are instruments, which allow the study of land use, as well as the occupation in real time (MORANDI et al., 2018).

In this process, machine learning is found (SAMBATTI et al., 2019; OLIVEIRA; CÂMARA, 2019; GILL et al., 2019; RIZEEI et al., 2019). On the other hand, the use of Artificial Intelligence (AI) has also become an important tool in data resolution (SAMBATTI et al., 2019; GILL et al., 2019). Accordingly, discussions about sustainability have been acquiring other perspectives with the frequent use of geoinformation.

Consequently, there is a possibility of joining data with geographic databases among various institutions in the world (MIRTL et al., 2018). This process enables the completeness of information, in order to permit new allusions related to the quality of the environment (VIEGAS; ALMEIDA; SOUZA, 2018).

Geotechnologies are fundamental (SIMONETTI; SILVA; ROSA, 2019; LEITE; RODRIGUES; LEITE, 2018; MORANDI et al., 2018). This is due to the spread of free and open-source software in geoprocessing. There is also the use of mathematical models in which the purpose is outlined according to the research proposal (HARFOUCHE et al., 2019; SAYAD; MOUSANNIF; MOATASSIME, 2019). However, such georeferencing by artificial neural networks is a current perspective (BRUBACHER; OLIVEIRA; GUASSELLI, 2020).

It is not about computational knowledge alone, but about methodological knowledge for perfect data analysis (LEITE; RODRIGUES; LEITE, 2018). Thus, as GIS and remote sensing (MORANDI et al., 2018; REIS et al., 2018; THEVENIN; PIROLI, 2018; SIMONETTI; SILVA; ROSA, 2019; SCCOTI; ROBAINA; TRENTIN, 2019; SPETH et al., 2020), add, also, the increasing mathematical models of computational nature (HARFOUCHE et al., 2019).

Through georeferencing, it is possible to measure the phenomenon in space and assign to each geospatial data information, being wide the possibilities of geotechnologies (FIORESE; TORRES, 2019; ALMEIDA et al., 2020). In this panorama, one finds controversially the use of artificial intelligence, technologies for the study of natural resources.

Riparian forests, as important natural resources, are supported and protected by the Brazilian Forest Code (Law #. 12651, of 2012, amended by Law # 12727, of 2012) (MORANDI et al., 2018). Their maintenance, study, and

enforcement are facilitated by the use of geotechnologies (REIS et al., 2018; FIORESE; TORRES, 2019; ALVES; MARTINS; SCOPEL, 2020). The main objective of this article was to verify the relationship between remote sensing in natural resource management, as well as riparian forest PPAs and the use of artificial intelligence, given that they are important tools for studying riparian vegetation.

II. THE GEOTECHNOLOGIES SCENARIO

The use of geotechnologies becomes fundamental, due to the pressures that human activities perform on the environment (MEDEIROS; ALBUQUERQUE, 2019). This way, it is possible to use geoinformative technologies to make society more participatory and active in relation to environmental issues, and therefore, these actions should not remain only at the level of ideas (LEITE; RODRIGUES; LEITE, 2018; VIEGAS; ALMEIDA; SOUZA, 2018).

Leite, Rodrigues & Leite (2018) assert that geotechnologies become important tools, in view of being able to provide answers, as well as analyze the space, in the face of the pressure that economic development entails in the natural environment. They are tools aimed at maintaining life in the biosphere, besides being essential for the study of large areas and socio-environmental phenomena, telecommunication, defense, and economy.

A tool for data analysis, extraction and manipulation requires a set of methodological knowledge, being, moreover, necessary for the individual to develop multidisciplinary skills (LEITE; RODRIGUES; LEITE, 2018). It is urgent in this process to be acquainted with other areas of knowledge, such as programming language.

Geotechnologies, in addition to assisting in the study of natural resources, allow expanding the discussion of the issues on environmental quality. Therefore, the management of geographic space becomes more dynamic with the possibility of analyzing various spatial aspects, such as Hydrography, Pedology, Edaphology, Agriculture, Livestock, Climatology, and Vegetation. From this point, the biosphere becomes a field of analysis from the perspective of technology with emphasis on geoinformation (LEITE; RODRIGUES; LEITE, 2018; MORANDI et al., 2018).

Morandi et al. (2018), Simonetti, Silva and Rosa (2019) highlight the importance of geotechnologies in understanding the interrelationship between natural and cultural environments. Geoinformation is fundamental because, through access to geographic databases, multitemporality aids in the process of geodecision making

(REIS et al., 2018; SPETH et al., 2020), being special in the reconstitution of degraded areas.

Viegas, Almeida and Souza (2018), as well as Speth et al. (2020) stress that geotechnologies are employed in the management of urbanized areas, and its employment assists, mainly, the performance of public institutions before such issues as urban zoning. Moreover, it helps as a supervisory tool in the fulfillment of environmental conservation standardizations (SIMONETTI; SILVA; ROSA, 2019; TREVISAN et al., 2020).

The use of computational systems comes to be an important ally in various fields of knowledge, not restricted only to the ecological dimension. This favors the dynamic use of geotechnologies whose purpose is to strengthen the understanding and confrontation of environmental issues. To this end, as reiterates Sampaio (2019), geotechnologies help to understand the forms of power and appropriation of the environment by the Human Beings.

Simonetti, Silva & Rosa (2019) highlight, in this process, GIS and remote sensing, as also highlighted by Araújo, Bastos and Rabelo (2020), reiterated also by Medeiros and Albuquerque (2019). However, the bench study, done remotely should not discard the importance of the study on-site (ALMEIDA et al., 2020).

Scototi, Robaina & Trentin (2019), still, highlight the relevance that GIS has acquired as well as Speth et al. (2020), because it streamlines the research work, becoming an important resource for the perfect apprehension of phenomena. For this to occur, the use of computational systems are fundamental.

In this sense, Mirtl et al. (2018) highlights the importance of “big data” in the treatment of large volumes of data at a time when ecological movements have sought strengthening, since obtaining information in an integralized manner has been faster, and geotechnologies are components of this development.

Geotechnologies are essential in maintaining the quality of natural resources, since, with the development of these technologies, new methodologies for the study of land use have provided answers to the aggressions imposed on the environment (LEITE; RODRIGUES; LEITE, 2018; MORANDI et al., 2018; REIS et al., 2018; THEVENIN; PIROLI, 2018; VIEGAS; ALMEIDA; SOUZA, 2018).

III. SCENARIO OF DATA ANALYSIS IN GEOTECHNOLOGY

For image processing, in the view of Oliveira & Câmara (2019), science has resorted to and developed

algorithms, mathematical models for refinement of predefined data (HARFOUCHE et al., 2019; SAYAD; MOUSANNIF; MOATASSIME, 2019). These are technologies such as artificial intelligence, machine learning, deep learning, and neural networks, although these processes are interrelated, they are quite different (DIKSHIT; PRADHAN; ALAMRI, 2020).

The development of artificial neural networks has been made possible with the knowledge of brain neural networks (OLIVEIRA; CÂMARA, 2019). The authors highlight the importance of Convolutional Neural Networks for image processing. Marques Junior & Covolan (2018) reiterate its importance for the treatment of big data, as does Gill et al. (2019) and Jena et al. (2020). The difference between the two is in the number of layers (KLOMPENBURG; KASSAHUN; CATAL, 2020).

The study of georeferenced information through artificial neural networks is a significant aspect (BRUBACHER; OLIVEIRA; GUASSELLI, 2020). It stands out because of the increasing advancement of computational tools to process large amounts of data (SAMBATTI et al., 2019; HARFOUCHE et al., 2019). This process has enhanced artificial intelligence studies, one of the highlights of which is machine learning (SAMBATTI et al., 2019; OLIVEIRA; CÂMARA, 2019; GILL et al., 2019; RIZEEI et al., 2019).

Machine learning allows computers to develop processes capable of being built by experience, and hence the development of artificial neural networks. Moreover, the use of the artificial intelligence tool enables collection, as well as analysis of information for an instant decision-making (SAMBATTI et al., 2019; GILL et al., 2019; TIYASHA; YASEEN, 2020).

Consequently, it is a much-updated technical and scientific process (OLIVEIRA; CÂMARA, 2019; HARFOUCHE et al., 2019). Despite being based on mathematical models, several fields of the human sciences have benefited and aided its development, according to the authors. As an example, the data obtained by satellite images and the supervised classification methodology proposed in artificial intelligence (NETO; GONÇALVES; SENNA, 2020; MARQUES JUNIOR; COVOLAN, 2018; SAMBATTI et al., 2019; SAYAD; MOUSANNIF; MOATASSIME, 2019).

As techniques on artificial intelligence advance, computational systems have taken a deep insight (TINÉ; PEREZ; MOLOWNY-HORAS, 2019). This requires the improvement of search techniques and the refinement of information. Therefore, mathematical models based on computational data are increasing (HARFOUCHE et al., 2019). Segments such as Big Date (MIRTL et al., 2018;

SAMBATTI et al., 2019; SAYAD; MOUSANNIF; MOATASSIME, 2019; KHAN; GUPTA; GUPTA, 2020), as well as advancement in sensor and satellite types. They are the future-proof in the study of data, especially in geosciences (GIL et al., 2019).

With the use of artificial intelligence, remote sensing techniques are improved, as coupled sensors have provided data with excellent resolutions. In this process, the Internet of Things (IoT) tool gains importance to assist in the processes of obtaining data regarding some environmental phenomenon (SAYAD; MOUSANNIF; MOATASSIME, 2019; GILL et al., 2019; KHAN; GUPTA; GUPTA, 2020; BALTI et al., 2020). On the other hand, Gill et al. (2019), emphasize the trends of Block chain technology.

Rizeei et al. (2019) stresses that the association of these techniques with GIS software has enhanced data retrieval. Jena et al. (2020) reiterate the use of machine learning. All this reinforces the importance of Artificial Intelligence to address environmental issues (DIKSHIT; PRADHAN; ALAMRI, 2020). On the other hand, deep machine learning solves the human difficulty in analyzing information through data correlation (SENGUPTA et al., 2020).

IV. MATERIAL AND METHODS

This is a qualitative, quantitative and descriptive research, in which data were collected from the websites of governmental and research institutions and from research sources such as Science Direct, Google Scholar, Scielo and Resergate.

It was carried out in two moments during the first semester of 2021. Alves, Martins and Scopel (2020) reiterate that geotechnologies are a set of technologies. The search was carried out according to Table 1. To this end, only articles published in periodicals, that were both in English and Portuguese were catalogued, covering the period from 2018 to 2020. It is also worth mentioning that the choice of research sources was due to their relevance and coverage worldwide. The choice of the time was due to the need to discuss the current state of the art.

Table 1 – Relation Between Strings And Research Sources

String	Data source
Riparian forest permanent protection area AND remote sensing AND legislation AND artificial intelligence AND artificial neural network AND AI geospatial	Scielo and Google Scholar

permanent riparian forest protection area AND remote sensing AND legislation AND artificial intelligence AND artificial neural network AND geospatial IA	Resergate and Science Direct
--	------------------------------

Developed by the authors

In the second step, the identification, the segregation into tables, and the analysis of the data was done using key words to quantify and qualify the form of use and its applications in articles published in periodicals, in the data sources cited in the research.

V. DISCUSSION AND RESULTS

The Scielo data source reported zero results. However, the Google Scholar search platform returned 124 results, distributed as follows 05 articles (2018), 06 articles (2019), 05 articles (2020), theses (25), dissertation (50), article in proceedings (01), chapter (02), e-book (07), articles in symposium (03), pages without access (04), monograph (20). Considering, however, the data presented in Table 2.

Table 2 – Found In Scielo And Google Scholar (Relevant Researches)

Contents	Authors
Remote Sensing	(ALMEIDA et al., 2020)
Geotechnologies	(ALVES; MARTINS; SCOPEL, 2020)
Occupy river banking	(FIORESE; TORRES, 2019)
Remote sensing, use and land cover	(LEITE; RODRIGUES; LEITE, 2018)
Geoprocessing, preserved areas	(SIMONETTI; SILVA; ROSA, 2019)
Brazilian Forest Code, Riparian Forest, Remote Sensing	(MORANDI, et al., 2018)
PPA; Geographical Information System (GIS)	(SPETH, et al., 2020)
Permanent Preservation Area; Geoprocessing	(VIEGAS; ALMEIDA; SOUZA, 2018)

Developed by the authors

The data source Resergate presented 01 article (2018). Science Direct reported 37 results. Thus distributed 01 article (2018), 09 articles (2019), 27 articles (2020), and

pages without access (09). To this end, the most important data have been highlighted in Table 3.

Table 3 – Found In Resergate And Science Direct
(Relevant Researches)

Content	Authors
Artificial Intelligence (AI)	(HARFOUCHE <i>et al.</i> , 2019)
Artificial Intelligence	(GILL <i>et al.</i> , 2019)
Artificial Intelligence; Machine Learning; Remote Sensing	(SAYAD; MOUSANNIF; MOATASSIME, 2019)
Neural artificial network	(CHEN <i>et al.</i> , 2019)
Machine learning, GIS (Geographic Information System)	(RIZEEI <i>et al.</i> , 2019)
Machine learning; Deep learning; Artificial Intelligence (AI)	(DIKSHIT; PRADHAN; ALAMRI, 2020)
Deep learning; Machine learning;	(KLOMPENBURG; KASSAHUN; CATAL ,2020)
Artificial intelligence	(TIYASHA; YASEEN, 2020)
Artificial intelligence; Satellite imagery; Remote sensing	(KHAN; GUPTA; GUPTA, 2020)
Artificial intelligence; Machine learning; Remote sensing	(BALTI <i>et al.</i> , 2020)
Deep Neural Networks	(PATAN <i>et al.</i> , 2020)
Machine learning; artificial intelligence	(GHARAI BEH <i>et al.</i> , 2020)
Deep learning; Commercial satellite imagery	(WITHARANA <i>et al.</i> , 2020)
Machine learning; GIS (Geographic Information System)	(JENA <i>et al.</i> , 2020).
Deep learning	(YEKEEN; BALOGUN; YUSOF, 2020)
Deep neural network; deep learning	(SENGUPTA <i>et al.</i> , 2020)
Machine learning	(SHARMA <i>et al.</i> , 2020)
Machine learning	(ZEKIĆ-SUŠAC;

	MITROVIĆ; HAS, 2020)
Deep learning, Convolutional Neural Network	(OLIVEIRA; CÂMARA, 2019).
Geoprocessing	(NETO; GONÇALVES; SENNA, 2020)
Apprenticeships and Machine; Convolutional Neural Network	(MARQUES JUNIOR; COVOLAN, 2018)
Artificial Intelligence; Apprenticeships machine	(SAMBATTI <i>et al.</i> , 2019)
Geoprocessing	(BRUBACHER; OLIVEIRA; GUASSELLI, 2020)
Modelling of Complex Systems	(TINÉ; PEREZ; MOLOWNY-HORAS, 2019)

Developed by the authors

Both in Table 2 and Table 3, the data were categorized according to keywords, since they are important structural elements and highlight relevant topics of the scientific article (AQUINO, 2010). When compared, the categories reveal important aspects of technological development for geospatial data mining.

5.1 Remote Sensing and Applicability

Geotechnologies offer several possibilities to obtain data, among them, remote sensing. According to Leite, Rodrigues, & Leite (2018) information can be obtained in several ways in this method. Therefore, the existence of platforms in which sensors decode information captured by the earth's surface.

It is possible to study the images both qualitatively and quantitatively, since both complement each other. This data processing constitutes steps arising from and known as Digital Image Processing (DIP). For Leite, Rodrigues, & Leite (2018), it is a primary element in satellite image processing.

For the treatment of images, points out Leite, Rodrigues & Leite (2018), it is vital the knowledge of spectral characteristics that is contained in every object. With this in mind, it is necessary that elements of the environment be taken into account in this manipulation of the data (MORANDI *et al.*, 2018; REIS *et al.*, 2018; VIEGAS, ALMEIDA, SOUZA 2018; THEVENIN, PIROLI, 2018).

The environmental management, from the remote sensing, ceases to be a difficulty, especially in public institutions, in the way highlighted by Viegas, Almeida & Souza (2018), since it is possible to perceive and analyze the phenomenon independently of the presence of a researcher, becoming this another important tool for inspection (SAMPAIO, 2019; TREVISAN et al., 2020).

5.2 Use of Geographic Information System (GIS)

Science has a very important role in the process of maintaining natural resources, and to this end, it is necessary to use technology to assist in the maintenance of life (MIRTL et al., 2018; LEITE; RODRIGUES; LEITE, 2018; MEDEIROS; ALBUQUERQUE, 2019). The authors reaffirm the necessity of using big data and its importance in understanding anthropogenic actions, because of a huge amount of instantaneous information.

Trevisan et al. (2020) stress the importance in the utilization of GIS, as it allows the integration of spatial data and information to research geographic phenomena. However, a GIS software involves the apprehension of multidisciplinary knowledge (LEITE; RODRIGUES; LEITE, 2018; MORANDI et al., 2018; REIS et al., 2018; THEVENIN; PIROLI, 2018; VIEGAS; ALMEIDA; SOUZA, 2018; FIORESE; TORRES, 2019; MEDEIROS; ALBUQUERQUE, 2019; SAMPAIO, 2019; SIMONETTI; SILVA; ROSA, 2019; ARAÚJO; BASTOS; RABELO, 2020; SPETH et al., 2020).

As an example of GIS software used in geoprocessing, according to Table 4, the authors communicate the importance that this tool has acquired. This notoriety, also, occurs because of the popularization of geospatial data, computer systems, as well as constant improvement.

Table 4 – Relation Sig Software By Author

SIG Software	Reference
SPRING 4.3.3	Leite, Rodrigues and Leite (2018)
ArcGIS 10.3.1	Morandi (<i>et al.</i> , 2018)
ArcGIS 10.1	Reis (<i>et al.</i> , 2018)
ENVI 5.0	Thevenin and Piroli (2018)
ArcGIS 10	Thevenin and Piroli (2018)
ArcGIS 10.1	Viegas, Almeida and Souza (2018)
ArcGIS 10.2.2	Fiorese and Torres (2019)
ArcGIS 10.5	Medeiros and Albuquerque (2019)
ArcGIS	Sampaio (2019)
ArcGIS 10.4	Scoti, Robaina and Trentin

	(2019)
Envi 4.8	Scoti, Robaina and Trentin (2019)
ArcGIS 10.4.1	Simonetti, Silva and Rosa (2019)
Erdas 2014	Almeida (<i>et al.</i> , 2020)
ArcGIS 10.5	Almeida (<i>et al.</i> , 2020)
ArcGIS 10.1	Alves, Martins and Scopel (2020)
QGIS 2.16	Alves, Martins and Scopel (2020)
ArcGIS 10.2	Araújo, Bastos and Rabelo (2020)
ArcGIS	Garcia and Longo (2020)
ArcGIS 10.5	Speth (<i>et al.</i> , 2020)
ArcGIS 10.5	TREVISAN <i>et al.</i> , 2020

Developed by the authors

The amount of GIS software does not end as shown in Table 4, but highlights the importance that this technology has acquired and become necessary for the study of georeferenced information. It can be either free software or proprietary software.

5.3 The importance of APPs and the standardizing instruments

The failure to comply with the Federal Constitution of Brazil, as described by Speth et al. (2020), in order to ensure the urgent quality of life for all, and the environment, as provided in Article 225. This legal, political, and administrative aspect is also observed in specific normative regulations protecting natural resources (MORANDI et al., 2018; THEVENIN; PIROLI, 2018; VIEGAS; ALMEIDA; SOUZA, 2018).

In Brazil, the first normative instruction dealing with the Forest Code, according to the reporting agency of the Chamber of Deputies, was Decree # 23793, of 1934. Another change came with the enactment of Federal Law # 4.771, of 1965. In relation to subsequent legislation, it meant a breakthrough in discussions about the limits of PPAs, as well as their definition. Sequentially, the Federal Law # 12651, of 2012, which, in a short time of effectiveness, underwent modifications with the Federal Law # 12727, of 2012.

However, anthropic action is a recurring variable (VIEGAS; ALMEIDA; SOUZA, 2018). There is in this a historical non-compliance with the Law (THEVENIN; PIROLI, 2018; SIMONETTI; SILVA; ROSA, 2019; ALVES; MARTINS; SCOPEL, 2020). In this process, geoprocessing and artificial intelligence techniques become very relevant.

5.4 Discussion of the data

The summing of the two databases enabled the following results 07 articles (2018), 15 articles (2019), 32 articles (2020), dissertations (50), articles in proceedings (01), chapters (02), e-books (07), articles in symposia (03), pages without access (13), theses (25), monographs (20), totaling 162 works.

The relationship between geotechnologies and artificial intelligence in the study of natural resources has been discussed. Although the data reflect little publication on the subject in question, with respect to the breadth and the need for discussion of very important categories such as artificial intelligence, geotechnologies and riparian forest.

However, in the period analyzed it was observed a larger quantity of discussion of articles in the English regarding the use of artificial intelligence and the need to expand them in the Portuguese. This is due to the understanding of the use and occupation of land, through geotechnologies, which is an important tool that enables the study of natural resources and various socio-environmental phenomena that occur on the Earth's surface (LEITE; RODRIGUES; LEITE, 2018).

The use of the artificial intelligence tool in this process should enhance the relationship of the environment by man as a management tool (GHARAIBEH et al., 2020). However, the use of GIS and remote sensing software, despite the lower amount of relevant articles in Portuguese, their discussion was more extensive than the English data.

The digital image processing techniques that takes into account the methodological aspects of geospatial data analysis of satellite images through the supervised classification model, the use of artificial intelligence has stood out (NETO; GONÇALVES; SENNA, 2020; MARQUES JUNIOR; COVOLAN, 2018; SABBATTI et al., 2019; SAYAD; MOUSANNIF; MOATASSIME, 2019).

The study of Permanent Protection Area (PPA) using remote sensing and GIS software, with emphasis on riparian forests has proven satisfactory (MORANDI, et al., 2018; MEDEIROS; ALBUQUERQUE, 2019; SIMONETTI; SILVA; ROSA, 2019), mainly with methodological processes made through temporal cutting by sensor systems (THEVENIN; PIROLI, 2018; ARAÚJO; BASTOS; RABELO, 2020), which helps the elucidation of the phenomena (SPETH et al., 2020; ALMEIDA et al., 2020).

The development of new techniques allowing the relationship between AI and geotechnologies is necessary, because there is a process of degradation of riparian forests

and remote sensing has been shown to be important for the study of land use and coverage (ALMEIDA et al., 2020). However, the analysis only from this perspective is insufficient since it is necessary to consider the development of the anthropocentric process on water resources.

On the other hand, one may see the urgent necessity of management in a participatory way with the various sectors of society as the implementation of sustainable practices (ALVES; MARTINS; SCOPEL, 2020), since it is important the wide investigation with the purpose of identifying the pressures suffered by the hydric bodies (FIORESE; TORRES, 2019).

The use of GIS software in the analysis and collection of spatial data on vegetation located on river banks are indispensable (SIMONETTI; SILVA; ROSA, 2019; VIEGAS; ALMEIDA; SOUZA, 2018; MORANDI et al., 2018). The use of this tool, complementary for the analysis of geospatial data, in the papers presented in Portuguese was broader than in English.

VI. CONCLUSION

There is an important discussion and improvement in the use of geotechnologies, artificial intelligence, and GIS software concerning methodological processes for studying spatial data. This type of analysis of space from an ecological point of view has been strengthened with the new study possibilities that the development of AI makes possible.

It was not possible to verify, the existence of APP studies of riparian forests using artificial intelligence. Although its analysis by means of GIS software and RS are consolidated, but it is possible to verify that new techniques in geoprocessing are growing with the use of artificial intelligence.

The AI technologies applied to riparian forest management can result in a broad discussion about this important natural resource in order to better characterize water resources, since these computer systems can provide and analyze large volumes of data.

The period applied to the research presented itself as an obstacle to the discussion about the proposed objective. The search sources showed insufficient results, considering the existence of other databases, and there may be articles that are not linked to the period analyzed, as well as other languages. Therefore, it is suggested as future works research related to the development of artificial intelligence for the study of APP of riparian forests associated with geotechnologies.

REFERENCES

- [1] ALMEIDA, M. I. S. et al. Análise ambiental nas margens fluviais da Bacia Hidrográfica do Rio Vieira - município de Montes Claros/MG. Available at: <<https://periodicos.ufam.edu.br/index.php/revista-geonorte/article/view/6986/5619>>. Accessed on 7th September, 2020.
- [2] ALVES, W. S.; MARTINS, A. P.; SCOPEL, I. Análise da evolução temporal do uso e cobertura da terra na Bacia do Ribeirão da Laje, no sudoeste de Goiás, de 1987 a 2017. Available at: <<http://www.seer.ufu.br/index.php/caminhosdegeografia/article/view/42492/28723>>. Accessed 7th September, 2020.
- [3] ARAÚJO, T. M. S.; BASTOS, F. H.; RABELO, F. D. B. Análise Multitemporal do Uso e Ocupação do Solo no Corredor Ecológico do Rio Pacoti (Ceará) nos anos de 1985, 2000 e 2015. Available at: <<http://www.uel.br/revistas/uel/index.php/geografia/article/view/38616/27603>>. Accessed 7th September, 2020.
- [4] BRASIL. Law 12.727, 17th October 2012. Available at: <http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/L12727.htm>. Accessed 22nd November, 2020.
- [5] BRASIL. Câmara dos Deputados. Available at: <<https://www.camara.leg.br/noticias/211148-historico-do-codigo-florestal/#:~:text=Desde%20que%20foi%20criado%2C%20durante,o%20conceito%20de%20florestas%20protetoras.>>. Accessed 22nd November, 2020.
- [6] BRASIL. Constitution of Federative Republic of Brazil 1988. Available at: <http://www.planalto.gov.br/ccivil_03/constituicao/constituicao.htm>. Accessed 22nd November, 2020.
- [7] BRASIL. Law # 12651, 25th May 2012. Available at: <http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/12651.htm>. Accessed 22nd November, 2020.
- [8] BRASIL. Law # 4771, 15th September 1965. Available at: <<https://www2.camara.leg.br/legin/fed/lei/1960-1969/lei-4771-15-setembro-1965-369026-publicacaooriginal-1-pl.html>>. Accessed 23rd November, 2020.
- [9] FIORESE, C. H. U.; TORRES, H. Análise do uso de solo de áreas de preservação permanente e da qualidade hídrica dos rios Itapemirim, Jucu, Benvenente e Santa Maria da Vitória (ES). Available at: <<https://www.brazilianjournals.com/index.php/BRJD/article/view/1212/1073>>. Accessed 7th September, 2020.
- [10] GARCIA, J. M.; LONGO, R. M. Análise de impactos ambientais em Área de Preservação Permanente (APP) como instrumento de gestão em rios urbanos. Available at: <<https://www.periodicos.unimontes.br/index.php/cerrados/article/view/797/2145>>. Accessed 7th September, 2020.
- [11] LEITE, V. A. W.; RODRIGUES, L. P.; LEITE, E. F. Dinâmica do uso e cobertura da terra no município de Miranda-MS, Pantanal Sul. Available at: <[https://www.researchgate.net/profile/Emerson_Leite/publication/329645875_Dinamica_do_uso_e_cobertura_da_terra_no_municipio_de_Miranda-](https://www.researchgate.net/profile/Emerson_Leite/publication/329645875_Dinamica_do_uso_e_cobertura_da_terra_no_municipio_de_Miranda-MS_Pantanal_Sul/links/5c17acd4a6fdcc494ffb2b90/Dinamica-do-uso-e-cobertura-da-terra-no-municipio-de-Miranda-MS-Pantanal-Sul.pdf)
- [12] MEDEIROS, C. N.; ALBUQUERQUE, E. L. S. Geoprocessamento aplicado ao mapeamento do uso e cobertura da terra em áreas de preservação permanente do município de Caucaia, Ceará, Brasil. Available at: <<http://periodicos.uem.br/ojs/index.php/BolGeogr/article/view/36586/751375149979>>. Accessed 7th September, 2020.
- [13] MIRTIL, M. et al. Genesis, goals and achievements of Long-Term Ecological Research at the global scale: A critical review of ILTER and future directions. Available at: <<https://sci-hub.se/https://doi.org/10.1016/j.scitotenv.2017.12.001>>. Accessed 8th September, 2020.
- [14] MORANDI, D. T. et al. Diagnóstico da antropização em área de preservação permanente em segmento do Rio Jequitinhonha (MG). Available at: <<https://revistas.ufpr.br/biofix/article/view/60177/35712>>. Accessed 1th September, 2020.
- [15] REIS, F. A. G. V. et al. Mapeamento geoambiental do município de Casa Branca (SP) como subsídio ao planejamento territorial. Available at: <<https://www.revistas.usp.br/guspsc/article/view/148389/142018>>. Accessed 1st September, 2020.
- [16] SAMPAIO, S. A. Caracterização física do município de Ipiaú-BA: Representação cartográfica como subsídio a análise ambiental. Available at: <<https://periodicos.ufrn.br/revistadoregne/article/view/15584/11305>>. Accessed 4th September, 2020.
- [17] SCCOTI, A. A. V.; ROBAINA, L. E. S.; TRENTIN, R. Zoneamento geoambiental da Bacia Hidrográfica do Rio Santa Maria: sudoeste do Rio Grande do Sul. Available at: <<https://revista.ufr.br/actageo/article/view/5141>>. Accessed 7th September, 2020.
- [18] SIMONETTI, V. C.; SILVA, D. C. C.; ROSA, A. H. Proposta metodológica para identificação de riscos associados ao relevo e antropização em áreas marginais aos recursos hídricos. Available at: <<https://scientiaplana.org.br/sp/article/view/4437/2139>>. Accessed 3rd September, 2020.
- [19] SPETH, G. et al. Conflitos do uso de solo em Áreas de Preservação Permanente em Candelária (RS). Available at: <https://www.researchgate.net/profile/Barbara_Ribeiro4/publication/339733354_Conflitos_do_uso_de_solo_em_areas_de_preservacao_permanente_em_Candelaria_RS/links/5e797f0892851c3091391399/Conflitos-do-uso-de-solo-em-areas-de-preservacao-permanente-em-Candelaria-RS.pdf>. Accessed 7th September, 2020.
- [20] THEVENIN, J. M. R.; PIROLI, E. L. Uso e cobertura da terra no território Ayahuasqueiro em Rondônia: uma análise de arranjos institucionais por classificação orientada ao objeto. Available at: <<https://revistas.ufpr.br/raega/article/view/52146/34892>>. Accessed 1st September, 2020.
- [21] TREVISAN, D. P. et al. Environmental vulnerability index: An evaluation of the water and the vegetation quality in a Brazilian Savanna and Seasonal Forest biome. Available

- at:<
<https://reader.elsevier.com/reader/sd/pii/S1470160X2030100X?token=EC9A5E1A28559E127BBFECA729F59A43674EDF3E4D0FEDCBAF242B6A5EBDF0C1C16C7F6CDF7E7B1AA280F830C45DC83D>>. Accessed 8th September, 2020.
- [22] VIEGAS, S.; ALMEIDA, R. M.; SOUZA, F. S. A identificação das áreas de preservação permanente no município de Santarém, Estado do Pará, Brasil, a partir de técnicas de geoprocessamento. Available at:<
<https://periodicos.ufam.edu.br/index.php/revista-geonorte/article/view/4785/3999>>. Accessed 1st November, 2020.
- [23] OLIVEIRA, P. F.; CÂMARA, C. E. Análise de desempenho de um algoritmo desenvolvido para solução de deep learning utilizando redes neurais convolucionais para Análise de contraste de imagens. Available at:<
<https://revistas.anchieta.br/index.php/RevistaUbiquidade/article/view/1010/893>>. Accessed 11th February, 2021.
- [24] NETO, B. S. R.; GONÇALVES, N. V.; SENNA, C. F. Mapeamento geoecológico da Costa Atlântica Amazônica aplicado ao município de Quatipuru – Pará, Brasil. Available at:<
<https://www.brazilianjournals.com/index.php/BJAER/article/view/19462/15620>>. Accessed 11th February, 2021.
- [25] MARQUES JUNIOR, L. C.; COVOLAN, J. A, U. A aplicação de redes neurais profundas para detecção e classificação de plantas daninhas e seu estado da arte. Available at:<
<https://revista.univem.edu.br/REGRAD/article/view/2638>>. Accessed 11th February, 2021.
- [26] SAMBATTI, S. B. M. et al. Previsão de riscos de alagamentos e inundações com uso de inteligência artificial. Available at:<
https://seer.uscs.edu.br/index.php/revista_informatica_aplicada/article/view/6985/3048>. Accessed 11th February, 2021.
- [27] BRUBACHER, J. P.; OLIVEIRA, G. G.; GUASSELLI, L. A. Preenchimento de Falhas e Espacialização de Dados Pluviométricos: Desafios e Perspectivas. Available at:<
<https://www.scielo.br/pdf/rbmet/v35n4/0102-7786-rbmet-7786354067.pdf>> Accessed 11th February, 2021.
- [28] TINÉ, M; PEREZ, L.; MOLOWNY-HORAS, R. Fundamentos teóricos de modelagem em sistemas complexos. Available at:<
<https://www.seer.ufal.br/index.php/contextogeografico/article/view/8363/6489>>. Accessed 11th February, 2021.
- [29] HARFOUCHE, A. L. et al. Accelerating Climate Resilient Plant Breeding by Applying Next-Generation Artificial Intelligence. Available at:<
<https://doi.org/10.1016/j.tibtech.2019.05.007>>. Accessed 19th February, 2021.
- [30] GILL, S. S. et al. Transformative Effects of IoT, Blockchain and Artificial Intelligence on Cloud Computing: Evolution, Vision, Trends and Open Challenges. Available at:<
<https://doi.org/10.1016/j.iot.2019.100118>>. Accessed 19th February, 2021.
- [31] SAYAD, Y. O.; MOUSANNIF, H.; MOATASSIME, H. A. Predictive modeling of wildfires: A new dataset and machine learning approach. Available at:<
<https://doi.org/10.1016/j.firesaf.2019.01.006>>. Accessed 19th February, 2021.
- [32] RIZEEI, H. M. et al. Groundwater aquifer potential modeling using an ensemble multi-adoptive boosting logistic regression technique. Available at:<
<https://doi.org/10.1016/j.jhydrol.2019.124172>>. Accessed 19th February, 2021.
- [33] DIKSHIT, A.; PRADHAN, B.; ALAMRI, A. M. Pathways and challenges of the application of artificial intelligence to geohazards modelling. Available at:<
<https://doi.org/10.1016/j.gr.2020.08.007>>. Accessed 22nd February, 2021.
- [34] KLOMPENBURG, T. V.; KASSAHUN, A.; CATAL, C. Crop yield prediction using machine learning: A systematic literature review. Available at:<
<https://doi.org/10.1016/j.compag.2020.105709>>. Accessed 22nd February, 2021.
- [35] KHAN, A.; GUPTA, S.; GUPTA, S. K. Multi-hazard disaster studies: Monitoring, detection, recovery, and management, based on emerging technologies and optimal techniques. Available at:<
<https://doi.org/10.1016/j.ijdr.2020.101642>>. Accessed 22nd February, 2021.
- [36] BALTI, H. et al. A review of drought monitoring with big data: Issues, methods, challenges and research directions. Available at:<
<https://doi.org/10.1016/j.ecoinf.2020.101136>>. Accessed 22nd February, 2021.
- [37] JENA, R. et al. Earthquake hazard and risk assessment using machine learning approaches at Palu, Indonesia. Available at:<
<https://doi.org/10.1016/j.scitotenv.2020.141582>>. Accessed 24th February, 2021.
- [38] SENGUPTA, S. et al. A review of deep learning with special emphasis on architectures, applications and recent trends. Available at:<
<https://doi.org/10.1016/j.knosys.2020.105596>>. Accessed 24th February, 2021.
- [39] TIYASHA, T. M. T.; YASEEN, Z. M. A survey on river water quality modelling using artificial intelligence models: 2000–2020. Available at:<
<https://doi.org/10.1016/j.jhydrol.2020.124670>>. Accessed 4th March, 2021.
- [40] GHARAIBEH, A. et al. Improving land-use change modeling by integrating ANN with Cellular Automata-Markov Chain model. Available at:<
<https://doi.org/10.1016/j.heliyon.2020.e05092>>. Accessed 4th March, 2021.
- [41] AQUINO, I. S. Como escrever arquivos científicos: sem “arrodeio” e sem medo da ABNT. São Paulo: Saraiva, 2010.