Turbining the Leopold Matrix

Roberto Tenorio Figueiredo[1], Vivianni Marques Leite dos Santos[2], Jorge Luis Cavalcanti Ramos[2]

[1]PhD student of the Graduate Program in Agroecology and Territorial Development (UNIVASF) – Brazil
[2]PhD Professors of the Postgraduate Program in Agroecology and Territorial Development (UNIVASF) - Brazil

***Abstract*— *The conservation of natural resources is a fundamental issue, in addition to being, in many cases, regulated by laws and decrees. In Brazil, resolutions require a rigorous environmental impact assessment to be carried out and the EIA (Environmental Impact Study) and RIMA (Environmental Impact Report) to be generated in any projects with activities that potentially cause degradation to the environment. A widespread way of assessing environmental impacts is the interaction matrix known as the Leopold Matrix. Many scientific articles use the original or modified Leopold matrix to perform the assessment of environmental impacts, although they commonly point out disadvantages or limitations in the use of the matrix. The purpose of this article is to propose a new matrix, named "Leopold Turbinated Matrix", with the elimination of the identified disadvantages, in addition to enhancing the advantages, without visually loading the matrix, in addition to including new elements, which enhance its ability to evaluate and predict environmental impacts. For this, an in-depth study was carried out on the applications of the matrix based on national and international scientific and technological. The developed "Leopold Turbine Matrix"solve identified disadvantages or limitations, in addition to including new criteria, so that it constitutes a new powerful, efficient and comprehensive tool regarding the assessment of environmental impacts.*

***Keywords*— Leopold Matrix, Environmental Impact Assessment, Decision making.**

I. INTRODUCTION

The first discussions with the participation of representatives from different countries take place in June 1972, during the First World Environment Conference in Stockholm, Sweden. At this conference, an instrument of great importance for the preservation of the environment was created, the Environmental Impact Assessment – EIA [1].

An environmental impact can be defined as:

> "[...]any change in the physical, chemical and biological properties of the environment, caused by any form of matter or energy resulting from human activities that, directly or indirectly, affect: I - the health, safety and well-being of the population; II - social and economic activities; III - the biota; IV - the aesthetic and sanitary conditions of the environment; V - the quality of environmental resources". [2]

According to Batista et al [3], EIA is an aid tool in decision making, which aims to evoke all environmental factors, so that decisions take these factors into account when designing projects. The authors also emphasize that it is fundamental for the development of the conscious use of the scarce resources of the planet earth and can be conceptualized as the "[...] qualitative and quantitative interpretation of the changes, of ecological, social, cultural or aesthetic order in the environment" [3].

The EIA includes procedures to identify and classify potential impacts that an action may cause to the environment, predicting the dimension and losses of these impacting activities [4]. According to Sanguinetto [5], it must be carried out by specialist technicians, helping organizations to execute projects with less damage to the environment. Consultation and popular participation are integral parts of this assessment, making EIA a participatory tool for environmental management [6].

The Brazilian law No. 6,938, of August 31, 1981, states that the assessment of environmental impacts is one of the instruments of the National Environment

https://dx.doi.org/10.22161/ijaers.77.56 *ISSN: 2349-6495(P) | 2456-1908(O)*

Policy. This law establishes that, in an environmental impacts assessment, in addition to other elements, the Environmental Impact Report (RIMA) needs to be generated, which provides all considerations about the possible environmental impacts of a project and the Environmental Impact Study (EIA) that details all the technical analysis made by those responsible who must approve or not the project.

On the other hand, the Federal Constitution of 1988 also addresses the issue, in its chapter 4, article 225, § 1, item IV, with the requirement of the prior study of environmental impact for any installation of work or activity potentially causing significant degradation of the environment.

More recently, Law No. 12.305, of August 2, 2010, instituted the National Solid Waste Policy (PNRS), which regulates the guidelines for solid waste management with the objective, among others, of minimizing environmental impacts arising from the manufacture of goods or any impacting activity that generates waste that will need to be disposed of.

In this context, the aforementioned legislative documents are milestones that reveal the importance given by the federal government to the need for environmental impact assessment for the quality of life of future generations, although there is still evidence of accidents occurring [7]that could be avoided through inspection and monitoring, still incipient, from the government [8].

According to Pimentel et al [9], for the EIA to reach its objectives, its studies must follow some steps. These steps must be carried out cyclically, with feedback being made during the process. Are they:

- Identification. It constitutes a detailed analysis of the project so that it can identify all the impacting activities, their relations with each other and the consequences of each of these activities through the measurement of indicators.
- Prediction. Formed by a detailed analysis of the impacts, identified in the previous step, to determine the nature of the impacting activities, their magnitude, their extent and their effects.
- Evaluation. It is time to interpret, analyze and evaluate the data obtained in the previous steps, its importance and the need for its elimination, or at least, its mitigation.

One of the activities inherent to the analysis of environmental impacts, which makes up the EIA, is the Environmental Diagnosis, detailed below.

1.1. Environmental Diagnosis

The environmental diagnosis allows a broad view of the project to be studied and must be constituted by the enumeration and integral analysis of the resources of the environment to be affected by the impacting activities, including their interactions. The basic construction of an environmental diagnosis, takes into account three overlapping environments, the physical environment, the biological environment and the anthropic environment [10].

- Physical Environment: The physical environment is the entire structure that allows the development of life. The elements of this medium to be analyzed vary according to the type and size of the project, taking into account the local characteristics. Are considered factors physical, mainly: soil, climate and meteorological conditions, air quality, noise levels, geological and geomorphological formations, in addition to water resources, water quality and management[11].
- Biological Environment: The biological environment is formed by the local flora and fauna, including their interdependencies that involve the exchange of matter and energy. They must also be considered according to the type and size of the project. Are considered biological factors, mainly: terrestrial and aquatic ecosystems, in addition to those of transition[11].
- Anthropic Environment: Also known as socio-economic environment, the anthropic environment deals with the human being, his needs, capacities and relationships with others and with the environment around him. Like the others, they must be considered according to the type and size of the project. In this environment, the impacts on the communities directly or indirectly affected by the project, which are the communities residing in the project's impact area or those that, in a certain way, maintain some relationship with that place or with the people who live there. They are anthropic factors, basically: population dynamics, that is, their day-to-day activities, land use and occupation, living standards, social organization and productive and service arrangements, which can be affected by the project and its impacting activities [11].

Through the environmental diagnosis it is possible to identify the sensitive areas of the environment in relation to the project. With the diagnosis made, it is necessary to assess the environmental impacts. There are several methods capable of assisting the professional in this task.

1.2. Environmental Impacts Assessment Methods

The methods of assessing environmental impacts have been created and evolved by several researchers over the years and aim to clarify the importance of environmental change in a simple and standardized way [12].

According toSTAMM [10],people involved in the environmental impact assessment process need to know all the assessment methods, so that they can choose the most appropriate method for each specific project.

Among the main methods of assessing environmental impacts then the ad-hoc method, check lists, interaction networks [13], system diagrams, overlaying charts and matrices [14], with various applications published in the literature (articles with applications).

1.3. Leopold Matrix

Leopold's matrix was created by geologist Luna Bergere Leopold and his colleagues in 1971, in response to the 1969 United States Environmental Policy Act, which did not provide clear instructions on how to generate an environmental impact analysis report for one project [15].

The Leopold matrix presents a general and complete overview of the project's actions, the impacting activities resulting from it and the environmental conditions affected, allowing to verify which actions are most impacting and which environmental conditions are most affected [16].

Based on the study by Leopold [17], in general, the matrix does not exceed one hundred impactful activities and eighty-eight environmental conditions, totaling 8.800 interactions, and in most projects, these interactions are limited to between 25 and 50. The Leopold matrix can be presented in its reduced format and in its expanded format.

In their reduced format, the table lines indicate the environmental conditions that can be affected and the columns indicate the existing impacting activities that affect them. Each cell in the table shows exactly two pieces of information: the intensity of the impact and its degree of importance [18].These two pieces of information are the criteria for analyzing each impact. A model of the reduced matrix is presented in Fig.1.

		Impactful activities of project				
		Activity 01	Activity 02	Activity 03	Activity 04	Activity 05
Environmental conditions	CA 01	2 / 1	2 / 3	1 / 1		
	CA 02			1 / 4	10 / 5	3 / 4
	CA 03	1 / 2		2 / 3	1 / 4	3 / 3
	CA 04	2 / 2				1 / 1

Fig.1: Leopold matrix reduced

Source: Adapted from Leopold et al [17].

The model presented in Fig.1contains five impacting activities and four environmental conditions. Some of the intersections are blank, representing that the impacting activity does not affect that environmental condition. In the others, it is possible to observe two values. The top number represents the intensity (magnitude) of the impact, in relation to the environmental condition of the interaction. The higher the intensity, the more affected the indicated environmental condition will be. The bottom number represents the importance that the impact has on nature. There is no standard to measure importance, however, the greater the value, the greater the perception and sensitivity of the impact in relation to the physical, biotic and anthropic means. The numerical values presented in the matrix can vary, generally, from 1 to 10 or from 1 to 100 [17].

The values of the reduced matrix can be positive or negative, indicating whether the impact is beneficial, in the case of positive or harmful values, in the case and negative values [15].

In its expanded format, the table has a subdivision for each impacting activity. Thus, an impacting activity can generate one or more environmental impacts for a given environmental condition. Each environmental impact has its intensity and importance analysis registered in the matrix [17]. A model of the expanded matrix is shown in Fig.2.

Despite having been made with a specific purpose, the Leopold Matrix assumes a very general character and can be used to evaluate most projects that can cause environmental impacts [15].

	Impacting activities														
	Ativ. 01			Ativ. 02				Ativ. 03			Ativ. 04				Ativ. 05
	Imp. Ambiental 01	Imp. Ambiental 02	Imp. Ambiental 03	Imp. Ambiental 01	Imp. Ambiental 02	Imp. Ambiental 03	Imp. Ambiental 04	Imp. Ambiental 01	Imp. Ambiental 02	Imp. Ambiental 03	Imp. Ambiental 01	Imp. Ambiental 02	Imp. Ambiental 03	Imp. Ambiental 04	Imp. Ambiental 01
CA01	2/2	1/1	3/3	1/1	1/2	2/4	1/1	1/2	3/3	1/2					
CA02							1/2	5/5	2/3	1/1	2/2	1/1	2/2	1/2	3/4
CA03	1/3	2/4	1/2				1/2	3/5	2/3	2/4	4/6	2/1	2/3	1/2	3/3
CA04	1/6	2/4	4/5												1/1

Fig.2: Leopold Matrix Expanded

Source: Adapted from Leopold et al.[17]

Over time, it was realized that, in many cases, two criteria were insufficient to carry out an efficient environmental impacts assessment. Based on the literature review, it is clear that each author decides to create his own matrix, without any standardization, resulting in the lack of analysis of some criteria and relevant information, difficulty in making and other disadvantages that will be analyzed on a case-by-case basis.

The objective of this article is to create a framework for creating a new, more complete Leopold-derived matrix, named "Leopold Turbinated Matrix", with the compilation of all the criteria necessary for a rigorous evaluation, adding to each criterion a collection of information, which will leverage environmental impacts assessment work, providing the user with a simplified and consistent set of information for decision making.

II. MATERIAL AND METHODS

The research carried out in this article has a quanti-qualitative approach of an applied nature, as it generates knowledge for short-term use and is classified as qualitative-exploratory. In order to achieve this, documentary and bibliographic research was carried out in order to update, standardize and give greater completeness to the Leopold Matrix regarding the assessment of environmental impacts.

The methodological procedure was divided into 3 stages, described below.

1 - Conducting a literature review in order to deepen the concepts that involve the Leopold matrix. The original article of its creator and introductory studies related to the matrix were sought;

2 - Conducting a systematic review, in order to verify how the authors are using the Leopold matrix to assess environmental impacts, which elements are being used in the matrix and what are the disadvantages pointed out by these authors. This step was performed with searches in CAPES journals [19] for access CAFe, Scielo[20] and Scopus [21];

3 - Compilation of the identified advantages and disadvantages. From the obtained data, a proposal was made for a Leopold Turbinated Matrix that would enhance the advantages and mitigate or eliminate the disadvantages in the application of the original Leopold matrix.

III. RESULTS AND DISCUSSION

For a better understanding of the results, it is necessary to describe the applications already published for impact assessment using the Leopold matrix. Gebler et al. [22], for example, used this matrix to assess the impacts on strawberry production. The authors compared the method with another matrix used up to that moment, with gains for the Leopold matrix, with an extended Leopold matrix proposed, containing 17 environmental conditions, 9 of which are associated with the physical environment, 2 with the biotic environment and 6 with the anthropic environment. The matrix's standard criteria being maintained, and in its description, the impacting activities are not explicit, but directly, the forecast of the consequences of the environmental impacts that the activities may cause. The difference is in the addition of a column on the far right, indicating the total sum of the values presented in the matrix. The study points as a disadvantage in the use of the matrix, the impossibility of identifying indirect impacts and the fact of not considering spatial characteristics.

Cavalcante et al. [23] used the Leopold matrix, based on the analyzed perceptions, to quantify the environmental impacts in a cylinder factory with a total of 1.296 interactions. The analysis of this matrix generated several graphs that show important indexes of the identified impacts. This article describes the extended matrix with 16 environmental conditions of the physical environment, 4 of the biotic environment and 7 of the anthropic environment. It presents the impacting activity, an environmental aspect associated with the activity and the impacts that this activity can generate, totaling 43 environmental impacts in 10 impacting activities. The numerical values are placed according to the standard matrix and are considered 3 analysis criteria: Severity, Frequency and Classification. The difference is three columns placed at the end of the matrix, one with the total sum of each line, another with the sum of the potentially impacting activities and the third with the degree of importance of the impact, obtained from a survey conducted with local residents. It also includes two columns in the middle of the matrix, indicating an impact situation and the final destination. The article does not point out any disadvantages in using the Leopold matrix.

Martins [24] used the Leopold matrix to assess the environmental impacts of the rural remnants located in the hydrographic basin of the CórregoGrotão, Ceilândia (DF). This work uses an extended Leopold matrix, with 8 environmental conditions of the physical environment, 5 of the biotic environment and 9 of the anthropic environment. It presents 4 impacting activities with 16 environmental impacts generated. The values are placed according to the standard matrix and are considered 5 analysis criteria: character, importance, coverage, duration and reversibility. The difference is the inclusion of columns related to ecological relationships of impacts and the values placed in colored cells and with positive and negative signs. Both the signs and the colors indicate whether the impact is beneficial or harmful. As a disadvantage, the work points out the fact that the matrix does not allow evaluating the frequency of interactions or making projections over time, in addition to presenting great subjectivity, without identifying indirect or second order impacts.

Kielinga et al. [25] used the Leopold matrix to assess the environmental impacts on organic food production. The article presents the Leopold matrix extended with 14 environmental conditions, without differentiating the physical, biotic and anthropic means and 16 environmental impacts, without presenting the impacting activities. The values and criteria used are the same as in the standard matrix. The differential of the work is the use of colors to differentiate between positive and negative impacts. The article quote no disadvantages over the matrix.

Souza et al. [26] used the Leopold matrix to assess the environmental impacts of the APP Rancho TuttyFalcãoGurupi (TO). The article presents the reduced Leopold matrix with 5 environmental conditions, 2 from the biotic environment, 2 from the physical environment and 1 from the anthropic environment, being analyzed in 5 environmental impacts. The values and criteria used are the same as in the standard matrix. The differential of the work is the inclusion of a line in the table with the averages of the values presented per column, of the interactions performed. The article quote no disadvantages over the matrix.

Oliveira et al. [27] used Leopold's matrix to carry out an environmental diagnosis of the impacts that occurred at the source of the Córrego Mutuca, in Tocantins. The authors opted for the use of the reduced Leopold matrix, with only 3 environmental conditions, two from the physical environment and 1 from the biotic environment, with 7 environmental impacts being analyzed, not to mention the impacting activities. The values and criteria used are the same as in the standard matrix. The differential of the work is the inclusion of a final line of the matrix, to calculate the average of the values of each column. The article does not point out disadvantages about the matrix.

Sajjadi et al. [28] used the Leopold matrix to analyze the environmental impacts of the landfill in the municipality of Gonabad and other waste management options that could be implemented. Adjustments and modifications were made to the Leopold matrix to better analyze the problem, showing the flexibility that the matrix has to adapt to the most varied types of projects. The results showed that the landfill was the worst among the options available for the locality, presenting the main problems of this option. The article presents the reduced Leopold matrix, with 22 environmental conditions, however, it does not divide them between physical, biotic and anthropic medium. It presents 18 impactful activities. The values and criteria are placed according to the standard matrix. There are no differentials at work. The article states that all means of assessing environmental impacts have disadvantages, but does not directly point out the disadvantages of the Leopold matrix.

Josimovic et al. [15] used the Leopold matrix to analyze the environmental impacts in the construction of wind farms in Serbia, presenting the local population the environmental impacts in a simple and precise way. The article presents four reduced Leopold matrices, one matrix for each of the analyzed criteria. They are: magnitude, significance, probability and duration of the impact. The study contains an analysis of 16 environmental conditions, 6 of which are physical, 5 are biotic and 5 are anthropic. It presents 9 impactful activities, with each matrix addressing only one result, numerical or literal, regarding the analyzed criterion. The difference in the work is the use of letters to indicate the influence of the impact, besides including, in the matrix that uses numbers (magnitude), two columns, one with the sum of the values and the other with the average of values for each environmental condition. It also includes, in this numerical matrix, two lines, one with the sum and one with the average, for each impacting activity. The

https://dx.doi.org/10.22161/ijaers.77.56 ISSN: 2349-6495(P) | 2456-1908(O)

work does not point out the disadvantages of the Leopold matrix.

Falk et al. [29] used the Leopold Matrix to assess the environmental impacts of a tobacco production, with the identification of 61 interactions. This analysis made it possible to recognize the existence of negative impacts that could be mitigated and to observe scenarios where specialists could suggest changes to the project. They concluded that the matrix is an adequate tool for identifying the main environmental impacts, with flexibility and efficiency. With the matrix data, Falk et al. [29] also built graphics that helped to visualize environmental impacts. The authors used the reduced Leopold matrix, with 8 environmental conditions, 4 of which were physical and 4 anthropic. It presents 19 impactful activities, distributed among 8 stages of the process. It analyzes 5 criteria: value (positive or negative), order (direct or indirect), space (local, regional or strategic), time (short, medium or long) and dynamics (temporary, cyclical or permanent). The matrix has no numeric values. The differential at work is exactly the way the values appear in the matrix. Instead of putting numerical information, they put 5 letters indicating the classification of each of the criteria, allowing to differentiate positive from negative impacts, for example. The interaction matrix with letters instead of numbers is called by the authors "Leopold modified matrix". Another differential is to place in the matrix, the steps of the process that generate the impacting activities. The article does not point out the disadvantages of the Leopold matrix.

Rodrigues [30] used the Leopold matrix to assess the environmental impacts of the generation of solid waste on the UniFOATangerinal campus. The article presents the extended Leopold matrix, with 5 environmental conditions of the physical environment, 2 of the biotic environment and 4 of the anthropic environment. 11 impacting activities and their respective impacts are described. It analyzes 4 criteria: value (positive or negative), importance (small, medium or large), magnitude (scale of 1 to 3) and duration (short, medium, long). The matrix does not have numerical values, using ranges of values placed in the columns, with the addition of an X in the column corresponding to the interaction of the impacting activity. The differential of the work is the inclusion of a column indicating an impacting activity, whose benefit of the increase was not evaluated by the research. They also added a column describing the impact generated and a line, indicating the total markings for a given column. At the end of the process, another matrix is generated from the quantitative of markings. The article does not point out any disadvantages in Leopold's matrix.

Guimarães et al. [31] used the Leopold matrix to evaluate the environmental impacts of the processes used in the daily life of a printing industry. In this case, an extended Leopold matrix was elaborated, containing 28 impacting activities and their respective impacts, without separating the analysis by environmental condition affected by the activities, nor is it about the means physical, biotic and anthropic means, analyzing only the impact on the environment as one all. It establishes three criteria: Magnitude (small, medium or large), importance (not significant, moderate or significant) and duration (short, medium or long), with numerical values associated with each of the parametersof the criteria. The work differential is the columns included in the matrix: An indication of the stage to which each impacting activity belongs; another containing the total sum of the values associated with each environmental impact, another containing the total sum of the values associated with each stage of the process and a last column containing the percentage that each stage contributes to the sum of the total values of the entire matrix. The article does not point out any disadvantages in Leopold's matrix.

Landim et al. [32] used the Leopold matrix to evaluate the environmental impacts on the production of bricks from a pottery in the municipality of Caçapava do Sul (RS). The article presents the extended matrix with 20 environmental conditions, 9 of which are from the anthropic environment and the others are classified in the biophysical environment, combining the physical and biotic environmental in a single group. It presents 11 impactful activities with 25 environmental impacts generated. It only looks at the importance criterion. The matrix does not put numbers only colors indicating the importance of the impact (red for very important, yellow for little important and white for non-existent impact). The differential of the work is to have, in the matrix, a "submatrix" indicating the degree to which each impacting activity influences the generation of each of the environmental impacts generated. This gradation can be classified as: very significant, significant, little significant or irrelevant. The article does not point out any disadvantages in Leopold's matrix.

Valdetaro et al. [33] used the Leopold matrix to identify and characterize, quantitatively and qualitatively, the environmental impacts of forest development plantations, in the stages of implementation, maintenance, harvesting and transportation. The article presents the reduced Leopold matrix with 27 environmental conditions, 12 of which are physical, 9 are biotic and 6

https://dx.doi.org/10.22161/ijaers.77.56 ISSN: 2349-6495(P) | 2456-1908(O)

are anthropic. It totals 44 impactful activities and analyzes 6 criteria: value (positive or negative), order (direct or indirect), space (local, regional or strategic), time (short term, medium term or long term), dynamics (temporary, cyclical or permanent), plastic (reversible or irreversible). The matrix has no numeric values. The differential in the article is the way the values are placed in the matrix. Instead of putting numbers, they put 6 letters indicating the classification of each of the analyzed criteria. The article brings yet another matrix, with the same parameters, but this time with numerical values, one for each interaction. This value indicates the degree of change in environmental factors, according to the literal matrix, assessed as negligible (1 or -1), low degree (2 or -2), medium degree (3 or -3), high degree (4 or - 4), very high grade (5 or -5) or 0 for non-existent impacts, with positive values indicating a positive impact and negative ones otherwise. This second matrix inserts new lines that indicate, for each environmental condition, the number of impacts, the sum of the positive values, the sum of the negative values and the total sum of the positive and negative values. The article does not point out disadvantages of the matrix.

Almeida et al. [14] used the Leopold matrix to assess the environmental impacts of the ethanol production process, even generating graphs to assist in qualitative analysis. The article uses the reduced Leopold matrix with 13 environmental conditions, 4 of which are physical, 1 is biotic and 8 is anthropic. It identifies 14 impactful activities, distributed in 10 stages and analyzes 6 criteria: value (positive or negative), order (direct or indirect), spatial (local, regional or strategic), temporal (short, medium or long term), dynamic (temporary, cyclic or permanent) and plastic (reversible or irreversible). The matrix has no numeric values. The differential at work is in the way the values appear in the matrix. 6 letters are placed indicating the classification of each of the criteria. Interaction matrix with letters is pointed out by the authors as a method derived from the Leopold Matrix. The work also includes a column related to the stages of the process. The article does not point out the disadvantages of the Leopold matrix.

Freitas et al. [34] used the Leopold matrix to quantitatively assess the environmental impacts inherent to the forest harvesting process in eucalyptus plantations. Six matrices were assembled, three for each of the harvesting modules determined by the study, the Chainsaw + GuinchoArrastador and the Chainsaw + Forwarder (term used for large vehicles used to transport wood [34]). There were three evaluators in the process and each set up their matrix. The article uses the reduced matrix with 20 environmental conditions, being 8 from the physical environment, 9 from the biotic environment and 3 from the anthropic environment and identifies 7 impacting activities with analysis of two criteria: magnitude (with a scale of 0 to 5, being, in order, - no impact - negligible impact - low degree impact - medium degree impact - high degree impact - very high degree impact) and value (positive with the numbering of the positive or negative magnitude, with the negative sign in the magnitude). The numeric values are placed in the matrix. The differential of the work is the inclusion of columns to totalize: for each impacting activity, the total sum of positive impacts, the total sum of negative impacts and the general sum of impacts. The article does not point out the disadvantages of the Leopold matrix.

Souza et al. [35] used the Leopold matrix to assess, qualitatively, the environmental impacts arising from the manufacture of furniture at the Furniture Pole of Ubá (MG). The authors used a reduced Leopold matrix, with 25 environmental conditions, 10 from the physical environment, 7 from the biotic environment and 8 from the anthropic environment, identifying 28 impacting activities, divided into 4 phases, whose analysis was based on 6 criteria. They are: value (positive or negative), order (direct or indirect), space (local, regional or strategic), time (short term, medium term, long term), dynamic (temporary, cyclical, permanent) and plastic (reversible or irreversible). Numeric values are not placed in the matrix. The differential of the work is that, in the matrix, 6 indicative letters are placed, one for each parameter of the criteria, in relation to the impact. In addition, it has a column to indicate the phases of the project to which each of the impacting activities belongs. The article does not point out the disadvantages of the Leopold matrix.

Silva et al. [36] used the Leopold matrix to assess the environmental impacts caused by a plastic industry in its process of manufacturing waterproof clothing. The article presents the reduced Leopold matrix with 12 environmental conditions, being 3 from the physical environment, 1 from the biotic environment and 8 from the anthropic environment. It has 9 environmental impacts. The analyzed values and criteria are the same as in the standard matrix. The differential of the article is the inclusion of two columns, one indicating the average of the values and the other indicating the final index for each environmental impact analyzed. The article points out that the disadvantages of Leopold's matrix do not consider, in its analysis, indirect impacts and temporal and spatial aspects.

https://dx.doi.org/10.22161/ijaers.77.56 *ISSN: 2349-6495(P) | 2456-1908(O)*

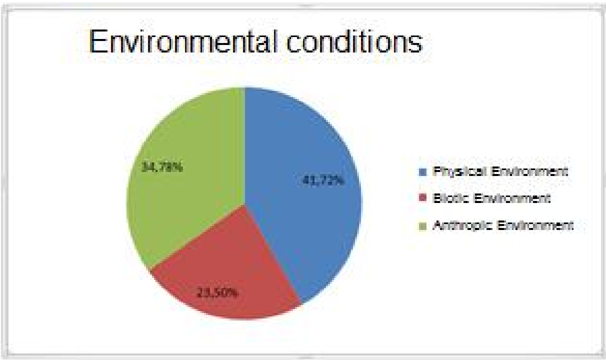
Vilhena et al. [37] used the Leopold matrix to evaluate the environmental impacts caused by the alteration of the relief in the construction of the access road to the surroundings of module II of the Amapá State Forest. The article presents the extended matrix, but does not consider environmental conditions, analyzing the impact on the environment as a whole. It presents 2 impacting activities and 8 impacts generated (4 for each activity). The values are placed in the matrix, which analyzes the criteria of the standard matrix (Magnitude and importance), but with parameters. The magnitude has, as a parameter, the extension (1 to 4), the periodicity (1 to 3) and intensity (1 to 3). The importance has, as a parameter, the action (1 to 4), the ignition (1 to 3) and the criticality (1 to 3). The differential of the article is a column that indicates how many points in the environment the impact happened. The authors did not point out any disadvantages of the Leopold matrix.

Magalhães et al. [38] analyzed the environmental impacts of paving the MG 307 highway in the municipality of GrãoMogol (MG). The article presents the extended matrix, does not define environmental conditions, but separates the environmental impacts into 11 impacts on the physical environment, 6 impacts from the biotic environment and 7 impacts from the anthropic environment, totaling 24 environmental impacts analyzed, in 3 impacting activities. It uses 6 criteria, being: nature (positive or negative), scope (local or regional), incidence (direct or indirect), temporality (temporary or permanent), reversibility (reversible or irreversible) and valuation (low, medium or high) . Numerical values are not placed in the matrix, which was filled with letters referring to the criteria parameters in each interaction. No differential was identified in the matrix used in this study in comparison to the original Leopold matrix, with the exception of using letters instead of numbers, as mentioned. The authors identified an disadvantage in the use of the matrix: not considering time, as it does not take into account immediate, temporary or definitive impacts. It is also noteworthy that the authors created a matrix for each type of environment, thus not assigning values to the transversal impacts, that is, not facilitating the visualization of simultaneous impacts in different environmental conditions.

It is worth highlighting the work of Stamm[10], who makes a complete survey of the methods of assessing environmental impacts, including the Leopold matrix. The case study of the work makes an assessment of environmental impacts in the Jacuí Thermoelectric Power Plant undertaking and brings several matrices, for several suggested scenarios and situations, focusing on the matrix that presents the sum of the averages and the totals of the environmental factors for the current scenario from the project. The Leopold matrix used contains 30 environmental conditions, 6 from the physical environment, 6 from the biotic environment and 18 from the anthropic environment, analyzing 32 impacting activities, using the criteria and values of the standard matrix, with negative and positive signs. The work has numerous differentials, and it is important to highlight the column that contains the averages and the total sum of the impact values. The work points, as a disadvantage of the Leopold matrix, the difficulty to distinguish the direct impacts from the indirect ones, the fact of not identifying the spatial aspects of the impacts, not considering the dynamics of the analyzed environmental systems, not identifying temporal characteristics and the presence of subjectivity in calculating the magnitude.

The Graph 1 contains a comparison between the percentages of environmental conditions based on their sum in each of the twenty research works described in this article.

Graph 1: Environmental conditions in the physical, biotic and anthropic environments.



Source: [The authors]

Thus, it appears that there is a predominance of the analysis of environmental impacts in physical environments, followed by those in anthropic and biotic environments, respectively, and that the referred percentages are not very different. Some are very specific to a region or a project, others really differ and must be considered and analyzed to compose the final result of this work.

Regarding the physical environment, we have the following analyzes per item:

- Soil: 18 articles analyze contamination, 10 erosion, 8 the increase in nutrients, 6 the topography change, 5 the occupation, 3 of the waste thrown to the soil and 1 deals with compaction.

https://dx.doi.org/10.22161/ijaers.77.56 ISSN: 2349-6495(P) | 2456-1908(O)

- Water: 22 articles analyze water contamination, 7 its availability, 5 the increase in consumption, 4 the silting of the rivers, 3 the change in the watercourse. Many items were cited by only 1 article, they are: interference with infiltration, water catchment sites, microclimate, water recharge, flood induction, instability of structures due to contact with water and surface factors.
- Air: 15 articles analyze air contamination, 6 solid particles, 6 gases and vapors and 1 change in wind movement.
- Noise: 8 articles analyze the increase in noise in the environment.
- Others: among other factors analyzed, we have: 3 articles analyze the compromise of natural resources, 2 the temperature, 1 the contribution to recycling, 1 the energy consumed by electronic devices and lamps, 1 general physical factors and 1 the changes in food chain.

Regarding the biotic environment, we have the following analyzes per item:

- Vegetation: 19 articles analyze the reduction or alteration of plant biodiversity, 5 the use of spaces with native vegetation, 4 the change in the natural cycles of plants and some items were mentioned by only one article, they are: the use of native vegetation, the impact on local agriculture, the impact on an existing crop, the improvement in vegetable hygiene and the natural regeneration under planting.
- Animal: 17 articles analyze the impact on a specific animal group, 12 the decrease in diversity, 3 the occupation of habitats, 2 the change in biological functions, 1 changes in the barriers and corridors used by fauna and 1 the proliferation of disease vectors in animals (insects).

Regarding the anthropic environment, we have the following analyzes per item:

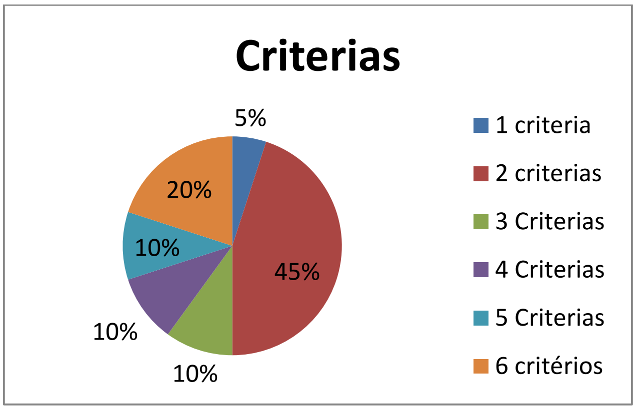
- Economy: 7 articles analyze the generation of jobs, 6 the increase in commercial activity and income, 6 the general impacts on the local economy, 5 the training of the workforce, 1 the increase in the workload and 1 the displacement of people and economic activities.
- Health: 8 articles analyze the impacts on human health and 3 the possible accidents that can occur.
- Landscaping: 5 articles analyze landscaping in general and 4 the visual impact of the proposed project.
- Quality of Life: 3 articles analyze the impacts on the quality of life of the people involved and 3 the population growth, which can interfere with the quality of life of local communities.
- Infrastructure: 4 articles analyze the infrastructure generated, 1 the use of land, 1 the quality of open spaces and 1 the change in the way people use and occupy land.
- Cultural: 2 articles analyze changes in the cultural pattern (lifestyle) of local communities, 1 the archaeological and cultural heritage and 1 the cultural heritage of the place.
- Acceptance: some factors of acceptance of the project, by the local communities are analyzed in the articles, being an article for each factor, they are: the acceptance in general, the general evaluation of the project's interference, the olfactory comfort, the thermal comfort, the fixation of man in the countryside and the disturbance of community life.
- Other factors of great importance are also analyzed. 5 articles analyze the quality of the final product, 4 the regional development and 2 the technology generated by the project.

The environmental impacts analyzed and their quantities are closely linked to the project, its consequent impacting activities and what it is intended to evaluate, therefore, there is no generalization of the results regarding the criteria, intensities and means where the impacts affect.

The Graph 2 contains the percentage of articles in relation to the number of criteria used. The majority (45%) strictly follow the Leopold pattern and analyze only two criteria: Magnitude and Importance. On the other hand, the sum of the other articles in which the authors choose a more careful analysis reaches 50%, using between 3 and 6 criteria.

Analyzing the criteria used, it is also verified that some criteria that are present in some works, are not considered in others. Adding the different criteria, it accounted for more than six criteria, all of which are considered relevant for this article.

Graph 2: percentage of articles by number of analyzed criteria



Source: [The authors]

The disadvantages pointed out by the authors, in the use of the Leopold matrix, numbered from 1 to 6, are listed below:

1. Does not identify indirect impacts, nor of second order;
2. Does not consider spatial or temporal characteristics;
3. Do not allows to evaluate the frequency of interactions;
4. Separate the environment in different ways, thus not assigning values to transversal impacts;
5. Not considering the dynamics of the environmental systems analyzed;
6. There is subjectivity in calculating the magnitude.

To mitigate or eliminate these disadvantages, new criteria must be included in the proposal for a new matrix. Based on the detailed survey, the proposal is that 12 criteria be taken into account, among which, the first six are listed by Almeida [14]. Are they:

- Value. Checks whether the impacting activity is beneficial or harmful. It can be qualified as “Positive”, when the activity improves the quality of a condition or “Negative”, when it causes damage.
- Order. It assesses whether the impact caused is the effect of an impacting activity or a secondary element of that activity. It can be classified as “Direct” when the impact is a simple cause and effect relationship, or “Indirect”, when the impact comes from an action derived from the activity.
- Spatial. Indicates the coverage of the impact area. Classified as “Local”, when the affected area is in the immediate vicinity or on the same property where the impacting activity occurred. “Regional”, when the impact affects areas that go beyond the immediate area of the area where the activity is carried out or “Strategic”, when the project affects the community, and may have national or even international scope.
- Temporal. It deals with the time elapsed between the performance of the impacting activity and the manifestation of the analyzed effects. It can be “Short term”, when the effect appears in a short period of time, to be defined according to the type of project. “Medium term”, when the manifestation time is average in relation to the type of project or “long term”, when the time for the effects to manifest is great in relation to the type of project.
- Dynamics. It concerns the length of time that the effects of the impact will be felt. It can be “Temporary”, when the impacts are felt for a certain time. "Cyclic", when the impacts are felt in certain periods of time or times of the year and "Permanent" when the effects of the impact do not stop manifesting in a period of time acceptable to society.
- Plastic. It makes reference if when the impacting activity ends, the impacts end with it. It can be “Reversible”, when the environment returns to its previous state, shortly after the end of the execution of the impacting activities or “Irreversible”, when the environment does not return to its previous state after a period of time acceptable to society.

Another 5 criteria are defined by econservation (16). Are they:

- Cumulativity. Which analyzes if there is any interaction between the impacts generated by the impacting activities of the project, and may even include other projects. It can be “present”, when the impact is influenced and/or influences other impacts or “absent”, when the impact does not suffer or generate any effect on other impacts.
- Magnitude. Analyzes the strength of the impact. It can be “strong”, when it has a big impact in absolute terms, that is, there is a big change in an environmental condition in quantitative and qualitative terms. “average”, when the impact is average in absolute terms or “weak”, when the impact is low in absolute terms.

https://dx.doi.org/10.22161/ijaers.77.56 *ISSN: 2349-6495(P) | 2456-1908(O)*

- Significance. It deals with the perception of the community in relation to the importance of the impact caused. It can be "big" when there is a great popular sensitivity in the affected communities. “medium”, when this sensitivity is medium or “small” if this sensitivity is low or none.
- Sensitivity. It concerns the sensitivity of the environment, according to the guidelines of the environmental diagnosis, of the area of influence of the impact. It can be “high” when there is a high sensitivity, “medium”, when there is a medium sensitivity of the environment or “low”, when the sensitivity is low or does not exist.
- Conditions. It makes a direct relationship between the impacting activity and the impact generated by it. It can be “normal”, when the impact happens under normal conditions, that is, whenever the impacting activity happens, the impact also happens or “abnormal”, when the impact generated only occurs under specific conditions, together with the impacting activity, for example, rainfall, or other climatic factors.

And a last criterion is defined and conceptualized by the authors, based on experience in impact assessment for proposals for action plans, which is described below.

- Resistance. It analyzes whether preventive or corrective measures can be taken to neutralize or minimize the effects of the impact. It can be: “irreducible”, when the measures will not influence the impact. “mitigable”, when the measures can reduce / circumvent the effects of the generated impact or “eliminable”, when the measures completely reverse the environmental impact caused by the impacting activity.

3.1. Leopold TurbinatedMatrix

Due to the high number of criteria, in the assembly of the new matrix, it was decided to place literal values, that is, non-numeric values, where each of the 12 letters used represents a parameter of the criterion according to the interaction. With this, it is estimated a considerable gain of information, without prejudice in the visualization and treatment of the data. Due to the significant increase in applications and benefits, the matrix is named “Leopold Turbinated Matrix”.

The Leopold Turbinated Matrix has a column to indicate the stage of the project and another to indicate the impacting activities.

The “Order” criterion separates the direct from the indirect impacts and the “Cumulativity” criterion, shows whether there is any transversal relationship between the criteria. It is still possible to include an indicative column that contains the first order impact line, for second order impacts, eliminating the disadvantages 1 and 4 pointed out by the authors.

The “Temporal” and “Spatial” criteria, together with the “Dynamics” criterion, give temporal and spatial characteristics to the environmental impact, also showing the frequency of the impact, eliminated the disadvantages 2 and 3 pointed out by the authors.

The disadvantage 5 linked to the dynamics of the systems is solved by the automation of the Leopold Turbinated Matrix, which can be constantly fed back, including with the possibility of forecasting results as an aid to decision making by comparing scenarios.

The Subjectivity (handicap 6) can be mitigated by including the criteria of "Magnitude", "Significance", "Sensitivity", "Plastic" and "Resistance". This information can be obtained, among other strategies, from technical opinions, results from the compilation of questionnaires carried out with the local population, etc.

Many works, based on numbers, had extra columns for information on the average and sum of values. With these results, the authors pointed out the most critical impacts. In Leopold Turbinated Matrix this criticality is measured in the form of colors. Numerical values are associated with the parameters of all criteria, according to their degree of influence on environmental conditions. These values are added together and the cells, whose sum reaches more than 2/3 of the maximum possible value, are painted red, referring to critical impacts. Those, whose sum of values do not reach 1/3 of the maximum possible value, remain in white and the rest are colored in yellow, that is, between 1/3 and 2/3, alluding to the need for attention.

An example of the Leopold Turbinated Matrix (Fig. 3) shows that all the information that was missing in the matrices previously used are present in the Leopold Turbinated Matrix, eliminating the disadvantages pointed out in the studies analyzed in this article.

IV. CONCLUSION

The Leopold matrix, with or without adaptations, ones have been successfully used to analyze environmental impacts or risks with a variety of applications, although with limitations, lack of dynamics and insufficient criteria. The compilation of data gave rise

https://dx.doi.org/10.22161/ijaers.77.56 ISSN: 2349-6495(P) | 2456-1908(O)

to Leopold Turbinated Matrix, a framework for the construction of the matrix, which inherited the advantages of the original standard matrix and which manages, without visually loading it, to eliminate or mitigate the disadvantages pointed out by the authors, adding various information of the analyzed criteria, bringing enormous benefits to those involved in any projects that have the potential to cause environmental impacts.

Among the main benefits are the ease of construction, the completeness of information, the identification of indirect impacts, consideration of temporal and spatial characteristics, among others.

For future work, the objective is to develop a system for creating and analyzing the matrix, aiming to provide dynamism in the process of assessing environmental impacts using Leopold Turbinated Matrix.

ETAPAS	ATIVIDADES IMPACTANTES	MEIO FÍSICO				MEIO BIÓTICO	MEIO ANTRÓPICO							
		AR		Recursos Hídricos	Recurso Edáfico	Flora / Fauna								
		Partículas Sólidas	Gases e Vapores	Contaminação	Contaminação do Solo	Redução da Diversidade	Econômico Local	Infraestrutura	Tecnologia	Qualidade de Vida	Saúde	Desenvolvimento Regional	Paisagismo	Qual. Prod. Final
Demonstração 01	Atividade da Demonstraç	NDELPIPFaGAAI	NDRCCRAFrMANM	NDRCCRPMéPANM	NDLMCRPMéPBAM	NDRMPRPFaMMN	PDLCCIPMéMMAE	PDRCPRPFaMBNI	PDLCCIAMéNBNM	NDL#P#PFrGB#M	NIECCR#MéGA#E	#LM###MéGMN	NDLLPIPFaMAAE	############
Demonstração 02	Outra Demonstração	PDLCTRPFrPBNI	NIECTRAMéGANM	PDLCCRPMéPBNI	NIECCRAFrPMNM	PDLCPIPFrMMNI	PIRMPIPMéMMAN	PDLCCR#MéMBNM	NIELC#PFMMNM	NDLCPIAFrMNNI	PDRCCRPMéMBAI	NIRMTRPMéMAA#	ND#LCRPMéMMAN	#DLLCIPMéMMNI

Fig.3: Leopold Turbinated Matrix

Source: [The authors]

V. ACKNOWLEDGMENT

I thank my advisors, my family and everyone who helped me and continue to help me in this research.

REFERENCES

[1] MMA. (2009). Caderno de Licenciamento Ambiental. Ministério do Meio Ambiente, Brasília.

[2] CONAMA. (17 de 2 de 1986). RESOLUÇÃO DO CONSELHO NACIONAL DO MEIO AMBIENTE Nº 001. Diário Oficial da União.

[3] BATISTA, I., BATISTA, I., SILVA, F., & LIMA, Z. (2017). Avaliação de Impactos Ambientais. XVII Simpósio Brasileiro de Geografia Física Aplicada, pp. 7188-7199.

[4] ENRÍQUEZ-DE-SALAMANCA, A. (01 de 2018). Stakeholders' manipulation of Environmental Impact Assessment. Environmental Impact Assessment Review, 68, 10-18.

[5] SANGUINETTO, E. (2011). Avaliação de Impactos Ambientais (AIA), Avaliação Ambiental Estratégica (AAE) e Sustentabilidade em Minas Gerais. Revista Labor &Engenho, 5(3), 100-120.

[6] JAY, S., JONES, C., SLINN, P., & WOOD, C. (05 de 2007). Environmental impact assessment: Retrospect and prospect. Environmental ImpactAssessmentReview, pp. 287-300.

[7] SILVA, D., & RANGEL, T. (2019). Impactos Ambientais causados pela mineração. III Seminário "Ensino, Pesquisa & Cidadania em convergência", 04: Pesquisa no Campo do Direito (Tomo I) , pp. 43-50.

[8] DIAS, E., & SÁNCHEZ, L. (juil-set de 2001). Deficiências na implementação de projetos submetidos à avaliação de impacto ambiental no estado de São Paulo. Revista de Direito Ambiental, 06(23), 163-204.

[9] PIMENTEL, G., & PIRES, S. (1992). Metodologias de avaliação de impacto ambiental: aplicações e seus limites. Revista de Administração Pública, pp. 56-68.

[10] STAMM, H. (2003). Método para Avaliação de Impacto Ambiental (AIA) em projetos de grande porte: Estudo de caso de uma usina termelétrica. Florianópolis: Tese (Doutorado em Engenharia de Produção) - Programa de Pós-Graduação em Engenharia de Produção, Universidade Federal de Santa Catarina.

[11] ARAUJO, N., & CESARIN, S. (2015). Diagnóstico Ambiental: Caracterização dos meios físico, biótico e antrópico. São Paulo: Cruzeiro do Sul.

[12] MARTIM, H., & SANTOS, V. (12 de 2013). Avaliação de impactos ambientais em empresa de mineração de cobre utilizando redes de interação. Revista Eletronica em Gestão, Educação e Tecnologia Ambiental - REGET, pp. 3246-3257.

[13] MORAES, C., & AQUINO, C. (10 de 2016). Avaliação de impacto ambiental: uma revisão da literatura sobre as principais metodologias. 5º Simpósio de Integração Científica e Tecnológica do Sul Catarinense – SICT-Sul.

[14] ALMEIDA, S., SANTOS, V., & TORRES, G. (12 de 2014). Avaliação de impactos ambientais do processo de produção de etanol utilizando método derivado da Matriz de Leopold. Revista do Centro do Ciências Naturais e Exatas , 48(4), 1443-1459.

[15] JOSIMOVIC, B., PETRIC, J., & MILIJIC, S. (2014). The Use of the Leopold Matrix in Carrying Out the EIA for Wind Farms in Serbia. Energy andEnvironmentResearch, 4(1).

[16] Econservation. (2017). Avaliação dos Impactos Ambientais. Técnico, Econservation, Estudos e Projetos Ambientais, Vitória.

[17] LEOPOLD, L., CLARKE, F., HANSHAW, B., & BALSLEY, J. (1971). A Procedure for evaluating environmental impact (Vol. (Circular 645)). Washington D.C.: US Geological Survey.

[18] MOHEBALI, S., MAGHSOUDY, S., & ARDEJANI, F. (11 de 2019). Developing a coupled environmental impact assessment (C-EIA) method with sustainable development approach for environmental analysis in coal industries. EnvironmentDevelopmentandSustainability .

[19] CAPES/MEC. (2020). Portal de Periódicos CAPES/MEC. Acesso em 04 de 2020, disponível em Portal de Periódicos CAPES/MEC: https://www.periodicos.capes.gov.br/

[20] SciELO. (2020). SciELO – Scientific Electronic Library Online. Acesso em 04 de 2020, disponível em SciELO – ScientificElectronic Library Online: https://scielo.org/

[21] ELSEVIER. (2020). Scopus. Acesso em 04 de 2020, disponível em ScopusPreview: https://www.scopus.com/

[22] GEBLER, L., & LONGHI, A. (2018). Aplicação da matriz de Leopold para avaliação expedita de impacto ambiental na produção de morangos: um estudo de caso em Ipê (RS). Ambiência, 14(3), 709-727.

[23] CAVALCANTE, L., & LEITE, A. (06 de 2016). Aplicação da Matriz de Leopold como ferramenta de avaliação dos aspectos e impactos ambientais em uma fábrica de botijões. Revista Tecnologia, 37(1), 111-124.

[24] MARTINS, E. (2014). Diagnóstico Ambiental da Bacia Hidrográfica do Córrego Grotão, Ceilândia - DF. Brasília: Dissertação (Mestre em Meio Ambiente e Desenvolvimento Rural Sustentável) - Programa de Pós Graduação em Meio Ambiente e Desenvolvimento Rural Sustentável PPG - MADER, Universidade de Brasília - UnB.

[25] KIELINGA, A., PRÁB, L., FONTOURAC, N., & SILVEIRA, S. (2015). Avaliação de aspectos e impactos ambientais: estudo de caso na produção orgânica de alimentos. Congresso de Engenharia Ambiental do Sul do Brasil.

[26] SOUZA, P., GLORIA, A., GONÇALVES, D., SANTOS, A., & SOUZA, P. (2016). Metodologias de avaliação de impactos ambientais da APP, Rancho Tutty Falcão Gurupi - TO. Enciclopédia Biosfera, Centro Científico Conhecer, 13(24), 704-714.

[27] OLIVEIRA , A., SOUZA , P., BENEDITO , B., GONÇALVES , D., & SANTOS , A. (2015). Recuperação para a nascente do córrego Mutuca em Gurupi - TO. Enciclopédia Biosfera, 11(22), 2447-2465.

[28] SAJJADI, S., ALIAKBARI, Z., MATLABI, M., BIGLARI, H., & RASOULI, S. (02 de 2017). Environmental impact assessment of Gonabad municipal waste landfill site using Leopold Matrix. Electronic Physician, 9(2), 3714-3719.

[29] FALK, D., RUBERT, A., VOESE, L., SOUZA, M., & SCHNEIDER, R. (2019). Estudo de caso: Emprego da Matriz de Leopold para a avaliação de impactos associados à produção de tabaco em uma propriedade no vale do rio Pardo. TECNO-LÓGICA, 23(2), 108-115.

[30] RODRIGUES, W. (08 de 2015). Avaliação ambiental do Campus do Tangerinal (UniFOA) com enfoque na geração de resíduos sólidos. CardernosUniFOA(28), 5-16.

[31] GUIMARÃES , T., TOMBINI , M., FERRO , M., KIELING , A., & MORAES , C. (06 de 2015). Avaliação de aspectos e impactos ambientais: estudo de caso em uma indústria gráfica. 6º Fórum Internacional de Resíduos Sólidos.

[32] LANDIM , A., BRAGA , V., OLIVEIRA , B., FIGUEIREDO , A., KEMERICH , P., & VARGAS , J. (2019). Impactos ambientais causados pela implantação e operação de olaria em Caçapava do Sul-RS. Holos Environment, 19(1), 83-97.

[33] VALDETARO , E., SILVA , E., SILVA , J., & JACOVINE , L. (2015). Conjugação dos métodos da matriz de interação e do check-list na avaliação quali-quantitativa de impactos ambientais de um programa de fomento florestal. Revista Árvore, 39(4), 611-622.

[34] FREITAS , L., MACHADO , C., SILVA , E., & JACOVINE , L. (2007). Avaliação quantitativa de impactos ambientais da colheita florestal em dois módulos. Ceres, 54(313), 297-308.

[35] SOUZA , C., SILVA, E., SILVA, J., GRIFFITH, J., & CORDEIRO, S. (2011). Avaliação Qualitativa de Impactos Ambientais de Indústria de Móveis, Pólo Moveleiro de Ubá – MG. Revista Agrogeoambiental, 3(1), 63-73.

[36] SILVA, A., &MORAES , J. (10 de 2012). Proposta de uma matriz para avaliação de impactos ambientais em uma indústria plástica. XXXII Encontro Nacional de Engenharia de Produção .

[37] VILHENA, G., & SILVA, O. (12 de 2017). Avaliação de impactos ambientais de rodovias no Módulo II da Floresta Estadual do Amapá. (C. d. Território, Ed.) Revista de Geografia e Ordenamento do Território (GOT)(12), 357-381.

[38] MAGALHÃES , I., MARTINS , R., & SANTOS , A. (12 de 2011). Identificação dos impactos ambientais relacionados à pavimentação da rodovia MG 307 no município de Grão Mogol - MG. Revista verde de agroecologia e desenvolvimento sustentável grupo verde de agricultura alternativa, 6(5), 10-16.

[39] NURFITRI, S., RAIHAN, M., PUTRI, M., SETIAWAN, A., GADE, M., & POHLMANN, T. (2018). Environmental assessment of Pari Island towards oil spill using Geographic Information System (GIS): a preliminary study. IOP Conference Series: Earth and Environmental Science. Sci. 162. 012008.

[40] SÁEZ, J. L., DÍAZ, S., & SÁNCHEZ, F. (2011). Antropización y Agricultura en el Neolítico de Andalucía Occidental. Menga 02, 2(1), 73-85.

[41] ALMEIDA, A. (11 de 2017). Problemas nos estudos de impacto ambiental - EIAs conforme percepção dos analistas ambientais do IBAMA. VIII Congresso Brasileiro de Gestão Ambiental, pp. 1-5.

[42] TURRA, A., AMARAL, A., CIOTTI, A., WONGTSCHWSKI, C., NOVELLI, Y., MARQUES, A., et al. (2017). Avaliação de impacto ambiental sob uma

https://dx.doi.org/10.22161/ijaers.77.56 *ISSN: 2349-6495(P) | 2456-1908(O)*

abordagem ecossistêmica: Amplicação do porro de São Sebastião. Ambiente & Sociedade, XX(3), 159-178.

[43] FERREIRA, L., & CANTARINO, A. (08 de 2011). Análise do processo de avaliação de impactos ambientais indiretos, cumulativos e sinérgicos nos estudos de impacto ambiental de grandes projetos do PAC. VII Congresso Nacional de Excelência em Gestão, pp. 1-20.

[44] CAPORAL, F., & COSTABEBER, J. (2004). Agroecologia: alguns conceitos e princípios (1ª ed.). Brasília: EMATER.

[45] KIELINGA, A., PRÁB, L., FONTOURAC, N., & SILVEIRA, S. (2015). Avaliação de aspectos e impactos ambientais: estudo de caso na produção orgânica de alimentos. Congresso de Engenharia Ambiental do Sul do Brasil.

[46] RESTREPO, J., ÁNGEL, D., & PRAGER, M. (2000). Agroecología. Santo Domingo: Centro para el Desarrollo Agropecuario y Forestal, Inc. (CEDAF).

[47] MENEZES, L. (2017). O Desenvolvimento da Agroecologia e as Instituições do Campo Científico Agrário. São Carlos: Dissertação de Mestrado. Universidade Federal de São Carlos.

[48] POLON, L. (2019). Geografia. Acesso em 21 de 02 de 2020, disponível em Estudo Prático: https://www.estudopratico.com.br/revolucao-verde/

[49] CAPORAL, F., & AZEVEDO, E. (2011). Princípios e Perspectivas da Agroecologia. Paraná: Instituto Federal de Educação, Ciência e Tecnologia do Paraná.

[50] BARRETO, H., SOARES, J., MORAIS, D., SILVA, A., & SALMAN, A. (10 de 2010). Impactos ambientais do manejo agroecológico da caatinga no Rio Grande do Norte. Pesquisa Agropecuária Brasileira, 45(10), 1073-1081.

[51] RODRIGUES, G. (2005). Sistemas de Avaliação de Impacto para Gestão Ambiental em Estabelecimentos Rurais. In: G. RODRIGUES, C. BUSCHINELLI, I. RODRIGUES, & M. NEVES, Avaliação de impactos ambientais para gestão da APA da Barra do Rio Mamanguape-PB (pp. 111-129). Jaguariúna: EMBRAPA.

[52] AGUIAR, R., & GANDOLFI, N. (1997). Zoneamento geotécnico geral do Distrito Federal: Procedimentos Metodológicos e sua Inserção na Gestão Ambiental. São Carlos: Tese de Doutorado - Universidade de São Paulo.