Mapping of Environmental Degradation in Regions and States of Brazil

NELSON GUILHERME MACHADO PINTO[1], DANIEL ARRUDA CORONEL[2] and BRUNO PEREIRA CONTE[3]
[123]Graduate Program in Business
[123]Federal University of Santa Maria
[123]Av. Roraima, nº1000, Prédio 74C, Santa Maria - RS
[123]BRAZIL
[1]nelguimachado@hotmail.com , [2]daniel.coronel@uol.com.br , [3]brunopconte@yahoo.com.br

Abstract: - The objective of this study is to measure the environmental degradation in states and regions of Brazil in order to map this phenomenon throughout the country from the construction of a Degradation Index (ID). Data were calculated for 137 Brazilian mesoregions. Thus, it was calculated the ID average for the 26 states and the Federal District and for the five regions that comprise the Brazilian territory. The Degradation Index in the country was approximately 57%, which shows that more than half of the country is degraded. The North and Midwest regions are the most degraded in the country. The results support the premise that regions with higher levels of poverty are more degraded, which is the case of the Northern Region. In addition, another hypothesis that environmental degradation is under direct influence of agricultural activities is also confirmed in the Midwest Region.

Key-Words: - Environmental Degradation, Degradation Index; Brazilian states; Agricultural; Poverty; Agroecology.

1 Introduction

The environmentis, for humans, a true source of energy, products and other aspects that leveraged and are still responsible for their development. However, because of human intervention in nature and the consequent impacts created by this situation, environmental issues have become important in global discussions. From the natural resource exploitation by humans, there are cases in which the man only give value to their aspirations. In such cases, they transform the environment, decreasing and leading to the shortage of natural resources. This situation was intensified from the First Industrial Revolution [24, 2].

In the event of the exploration occurring at a higher rate than the capacity of regeneration of the environment, it will become scarce, thus, the task to reconcile environmental preservation with the productive capacity of regions on the scope is a responsibility for those who are in charge of the economic dynamics [36]. Because of this dynamic, in the late 1980s proposals emerged, aiming to build environmental indicators to support the formation of public policies and the detailing of the activities performed by human on the environment in which they are inserted [7, 24].

Environmental degradation, in this scenario, emerges as an important topic within the studies of environmental impacts. This phenomenon can be defined as destruction, damage or wearing of the environment generated from economic activities and population and biological aspects [23]. It is clear, therefore, that environmental degradation is directly related to human interaction with nature. Moreover, agriculture emerges as one of the main responsible for this degradation process because it meets the demands of markets.

In this sense, agricultural activity provides some environmental events that cause environmental degradation such as fires, pollution from manure and pesticides, erosion and soil degradation, water pollution, deforestation, desertification and agricultural expansion [21]. This kind of activity causes, in most cases, impacts in the environment where it acts, however, an awareness of the producers as well as the use of means and methods for a more sustainable agriculture are measures that can provide a less harmful impact on the environment [3].

On the national scenario, the impact of agriculture is more evident, because this activity is important in the national economic context, leaving the environmental issues in the background [12]. The importance of this activity involves three factors: number of employees of the sector, development of foreign exchange via exports through its products and food supply for the population.

Regarding the economic development of a region, there is a biunivocal relationship between the degree of wealth of the population and environmental degradation [33, 27]. The existing connection, especially between poverty and degradation, is based on the assumption that individuals with lower incomes depredate the environment because they lack access to information, appropriate technology and sources of credit. Therefore, the economic aspect relating to this particular situation demonstrates that these individuals depredate the natural environment unconsciously, because they have as hort-term view and a low capacity to take risks, so they take such actions in order to maintain their survival [23, 13]. In the contrary, it is believed that individuals with higher income levels have a tendency of consuming more green products [27].

From this context, scientific researches emerged to measure the environmental degradation, seeking to explain its main causes [23, 41, 12, 9, 28]. The measurement of this phenomenon occurred through the construction of a Degradation Index (ID), which emerged as a proxy to determine the degradation area of a given region [41].

Following this theme, the overall objective is to measure the environmental degradation of the Brazilian states and regions in order to map this phenomenon across the country from the construction of a Degradation Index (ID). Supported by the framework here presented, two research hypotheses arise: (H1) Environmental degradation is more evident in the Brazilian regions of greatest agricultural activity, and (H2) the less developed regions of Brazil have become more economically degraded.

The importance that has been given to the environmental impacts made the scientific research field led many researchers to quantify, through the ID, the impacts of changes in the environment, seeking to identify the determinants of environmental degradation in several locations. However, studies of the degradation index are dispersed by several Brazilian regions; therefore, it is not possible to verify how this phenomenon manifests itself across the national unity in order to be compared.

This article is structured, besides this introduction, in four sections. In the second section, the theoretical references are presented. In the third, it is presented the methodological procedures applied and in the next section, the results are discussed and analyzed. Finally, the main conclusions of the study are presented.

2 Theoretical References

The theoretical basis of the study is divided into two sections. The first section lists the key factors which make up the environmental degradation and its associated impacts on nature. Subsequently, in the second section are presented and discussed practical applications in academic studies on the topic of environmental degradation.

2.1 Determining factors of environmental degradation

The tendency to environmental degradation is a consequence of some practices and attitudes taken by economic and social agents within the environmental dynamics. Thus, this phenomenon derives from causing factors, among which it must be highlighted the intensive use of mechanization, fertilizers, pesticides, irrigation, deforestation, the burning of garbage and manipulating genomes. Such practices, when applied improperly, affect the ecological sustainability, affecting the soil cover and watersheds [9].

The factors that cause environmental degradation can be seen in Figure 1.

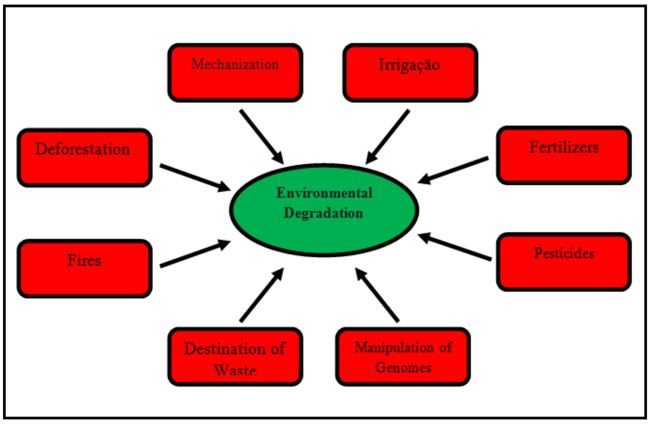

Fig.1 Determinant factors of degradation
Source: [30]

Agricultural activity acts on the environment unsustainably regarding its production and because of that, it causes environmental impacts such as emissions of greenhouse gases through burning and deforestation, silting of rivers, desertification, salinization and eutrophication [35, 11, 10]. The modernization of agriculture can be understood as one of the major responsible for environmental degradation, which can be caused by deforestation, the use of toxic products and by mechanization, which compacts the soil [19].

According to Pais *et al.* [28], prioritizing productivity without taking into consideration the environmental responsibility is the main issue that causes environmental degradation from the modernization of the countryside. Another aspect highlighted by the authors is the degradation of the environment from carelessness regarding the waste generated by agricultural activities, which may be due to the intensive use of capital or lack of production efficiency. Moreover, the intensive use of soil degrades matter and compacts it, by the use of heavy machinery [15]. This process is enhanced by agricultural modernization, which aggravates environmental issues [4].

The agricultural development model adopted in Brazil, at its beginning, had in general, little concern regarding environmental issues. Consequently, there is a certain lack of preparation in the use of machinery and agricultural inputs, best known as pesticides. The incorporation of this technology has an important role in improving agricultural productivity, because it reaches the so-called target organisms, namely, the pests. However, when there is a nonspecific action of these compounds, there is a side effect on the environment, causing environmental degradation, as well as incidents of human and other living beings contamination [1, 34].

With respect to cattle raising, the environmental impact of this activity is proportional to the relative intensity with which it is practiced, as well as the availability of natural resources of the area [21]. Besides cattle activity, other sources of impacts on the environment are burning, deforestation and irrigation that originates from the cattle farmers´ activities and occur in areas of great biodiversity of species. Regarding environmental degradation, deforestation of areas is usually the first step of this process [38]. In irrigated areas, the intensification of farming is a characteristic, which results in an intense use of soil, causing deterioration in the structure and often causing its compaction [25].

The use of fertilizers is another aspect approached in this study that affects the environment and, although it provides short-term fertilization for crops, its intensive and inappropriate use compromise long-term fertilization, the same caused by pesticides, affecting human health. Additionally, irrigation also aggravates the degradation, because it can cause serious damages to hydrography, besides promoting the leaching of fertilizers, polluting lakes and rivers and causing soil erosion [15].

Other factors that can be considered as determinants of environmental degradation by agriculture and cattle raising are the garbage disposal and handling of genomes. In modern consumerist society, the production of waste by humans tends to grow increasingly [36]. Measures should be taken by the agencies responsible for each region in order to give a correct destination to the waste without harming the environmental dynamics. In relation to the manipulation of genomes, which is characterized by modifications that aim to make the plants genetically more productive, but are dependent on the intensive use of pesticides and fertilizers, also cause the same impacts previously mentioned [15].

Even with all matters arising from degradation, there is the possibility to develop a sustainable economy. The process of environmental exploration by humans must be planned and measures should be taken to enhance the positive impacts and minimize the ones that are negative. Through this process, it is possible to obtain effective gains for both the environment as for the socioeconomic dimension of society [3].

From the context of environmental crisis in the last decades, agroecology became increasingly relevant. The practices that constitute the field of agroecology emerge as alternative models of industrial agriculture originated from the Green Revolution [39]. This subject was consolidated due to questions raised regarding current paradigms of economic and technological rationality. Given this scenario, the society started to internalize and consolidate a set of values and principles to guide a new production rationality aimed at greater social equity and ecological sustainability [20].

2.2 Empirical evidences

Environmental degradation, based on the methodology of building an index, has its work originated in studies on desertification processes, which can be considered a more advanced stage of degradation [23]. According to Lemos [22], the rate of desertification lacked the ability to capture the percentage of devastation in a determined region of study to which it was being subjected. Thus, it only became possible after the construction of an Environmental Degradation Index [23].

The literature regarding the subject shows that some authors have proposed to analyze the environmental degradation in the Brazilian scenario by building a Degradation Index and multivariate analysis. Among those worth mentioning are the studies of Lemos [23], Silva and Ribeiro [41], Fernandes, Cunha and Silva [12], Cunha *et al*. [9] and Pais *et al*. [28].

The study by Lemos [23] shows the entire construction of the ID. Aiming to map the environmental degradation of the cities of the nine northeastern states, the author found that more than half of the cities in the region live with a reality of more than 80% degradation, with the state of Bahia being the most degraded. Furthermore, the author estimated that nearly 8 million people in that region live in areas affected by levels of degradation higher than 60%.

The work of Silva and Ribeiro [41] estimated an ID as a measure of degradation intensity of the cities of the Acre State. The authors found, as a result, rates of degradation of low levels, averaging 30.74% for cities in the Acre State, with only some regions that were exceptions to that value found. Therefore, it was evident, in the authors' view, that Acre has a good state of conservation. However, some indicators in certain areas showed high degradation.

Moreover, in order to quantify the level of degradation of the cities from the state of Minas Gerais, the study by Fernandes, Cunha and Silva [12] built an index focusing on degraded area of the cities. The main results point to a high rate of degradation of the cities, about 86%, and 40% of those cities studied showed an ID equal to 1, obtaining thus the maximum value of the index. For the authors, these results are associated to the intensive way in which the process of development of Minas Gerais occurred, leveraged by economic factors.

The study by Cunha *et al.* [9] adopted the approach that environmental degradation is a direct result of agricultural exploitation. The authors evaluated variables related to intensive land use, technology (mechanical, biochemical, electrical and hydraulic) and modernization for the region of the Brazilian Cerrado, in the period between the years of 1995-1996. The results demonstrated micro-regional inequalities, in which the Northwest of Minas Gerais, the South of Goiás and the Southeast regions of Mato Grosso showed higher levels of environmental degradation, while the regions of Piauí, Tocantins and Maranhão had lower mean values of the index.

The work of Pais *et al.* [28] also adopted an approach that environmental degradation is directly related to agriculture. The work had a sits scope the objective tocheck this issue for the state of Bahia in 2006. As a result, the authors demonstrated that the cities from the central region of the state present a low standard of degradation. However, other regions of the state, namely the Mid-South and South mesoregions, showed a high level of environmental degradation and so it demonstrates heterogeneity among cities in Bahia regarding this matter.

Besides the work originated from the methodology created by Lemos [23], which have a more applicable approach to the socioeconomic level, there are other works that also study the environmental quality of certain regions [23, 37, 7, 13, 36, 42, 19, 40]. Moreover, there are studies on environmental resources across the socioeconomic development of countries that are considered classics and have had influenced the formulation of many public policies such as Limits to Growth and Report of the Club of Rome.

Finally, there are studies that have a different approach, being derived from natural and exact sciences. These studies evaluate the intensity of environmental impacts by human activities or by agriculture from a qualitative approach [32, 6, 3, 8, 21, 43].

3 Methodological Procedures

The present work is based on previous studies in the literature that used a specific methodology for the creation of an Environmental Degradation Index (ID). This index has emerged as a proxy for environmental degradation of a region used as an object of study [41]. The research, as well as quantitative, can also be considered descriptive, since observations and analyzes will be performed in order to record and correlate the phenomenon without manipulating them [31].

From previous studies on the topic, [23, 41, 12, 9, 28], it is noteworthy the multidimensional nature of environmental degradation, because the magnitude of this problem requires the consideration of a set of variables of local characteristics. Thus, because it involves variables that cover different aspects, the multivariate analysis, specifically the technique of factor analysis, it is the most suitable for this purpose [9].

This method discusses the problem of analyzing the correlations between a large group of variables by defining a set of common underlying dimensions, called factors. Factor analysis has as main objectives the summary and data reduction, as well as enabling the identification of variables representative of a group of variables for the use in subsequent multivariate analyzes [17].

A model of factor analysis according to Mingoti [26] is given, generally, in a matrix form, which can be expressed as follows:

$$X_i = a_{ij}F_j + \varepsilon_i \tag{1}$$

Where:
$X_i = (X_1, X_2, \ldots, X_p)^t$ is a transposed vector of observable random variables;
a_{ij} = is a matrix (p x m) of fixed coeficients called factorial charges, which describe the linear relationship of $X_i$and F_j;
$F_j = (F_1, F_2, \ldots, F_p)^t$ is a transposed vector (m < p) of latent variables that describe the unobservable elements of the sample; and
$\varepsilon_i = (\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_p)^t$ is a transposed vector of random errors, corresponding to errors of measurement and the variation of X_i, which is not explained by the commom factors F_j.

The fact that the variables are presented in different values shows the need for its standardization. The execution of this procedure relies on the problems that data arranged in different ways or processed incorrectly may provide in surveys [16]. It is therefore desirable to make objects of study comparable, reducing the effects of different scales [5]. The procedure of standardization of variables is given by:

$$Z = \frac{(X_i - \bar{X})}{S}, i = 1, \ldots, n \tag{2}$$

Where:
Z = standardized variable
X_i = variable to bestandardized
$\bar{X}$ = average of all observations
S = standard deviation of sample

From the standardization of observable random X_i, this may be replaced by the vector of standardized variables Z_i, in order to solve the problem of differences in scale unit as shown by Equation 2 [26]. Thus, Equation 1 can be rewritten as the following equation:

$$Z_i = a_{ij}F_j + \varepsilon_i \tag{3}$$

In order to construct the ID, it is necessary to estimate the scores associated with each factor after orthogonal rotation. In the present study, it was applied the use of orthogonal transformation of the original factors by the Varimax method, which presents a simpler structure to be understood because it maximizes in a single factor the correlations of each variable [17]. Finally, in order to determine whether the factor analysis fits to the data model, it was used the tests of Bartlett Sphericity and the Criterion of Kaiser-Meyer-Olkin (KMO). The first gives the statistical probability that the correlation matrix has significant correlation between at least some of the variables, that is, it compares the population correlation matrix to the identity matrix. In order for the data to be suitable for this analysis, the result of this test should be the rejection of the null hypothesis, in other words, the equality of matrices. The other test, KMO, checks the adequacy of the data from the creation of an index that ranges from 0 to 1, which compares the simple and partial correlations between variables, and in which values greater than 0.5 show that the data are suitable for factor analysis [29, 17, 26].

Subsequent to this analysis is that the ID can be built. The estimation of this index is divided into two stages. The first consists in building the so-called Partial Degradation Index (IPD), from the multivariate analysis. After conducting the factor analysis, the factors were obtained, as well as the factor scores and the proportion of variance explained by the factors. The calculation of the index of partial degradation can be given by [23]:

$$IPD_k = (\Sigma_{j=1}^{p} F_{ij}^2)^{1/2} \tag{4}$$

Where:
IPD_k is the rate of partial environmental degradation of k-thmesoregion;
$\Sigma_{j=1}^{p} F_{jk}^2$ is the addition of the squares of the j-th factorial score of the k-thmesoregion

It is expected that the factorial scores for each mesoregion have symmetrical distribution around the mean zero. Thus, half of the mesoregions will present values with positive signs and the other half will have a negative sign, which indicate the regions considered most degraded. In order to avoid that high negative factorial scores increase the magnitude of the indices associated with these mesoregions, it is necessary to undertake a transformation of the factorial scores in order to bring them all to the first quadrant [23]. This procedure should be performed before the estimation of IPD and it is algebraically expressed as:

$$F_{jk} = \frac{(F_{jk} - F_j^{min})}{(F_j^{max} - F_j^{min})} \tag{5}$$

Where:
F_{jk} are the factorial scores;
F_j^{max} is the maximum value observed for the j-th factorial score associated with the k-thmesoregion, and
F_j^{min} is the minimum value observed for the j-th factorial score associated with the k-thmesoregion;

The following stage consists in the construction of the Environmental Degradation Index (ID) that is performed by estimating the IPD of the weights given to each factor through regression analysis with the IPD as the dependent variable and indicators used in the construction of ID. It is worth mentioning that the IPD can be used to rank the mesoregions regarding the level of degradation. It is not meant to estimate the percentage of degradation of the mesoregions, which is determined by the ID [23]. This procedure can be defined as:

$$ID_k = \Sigma_j^p \beta_j X_i \ ; e\ \Sigma\beta_j = 1 : j = número\ de\ fatores\ encontrados \quad (6)$$

Where:
ID_k is the rate of environmental degradation for the k-thmesoregion;
β_j is the weight assigned to each factorial score, from the parameter value found in the regression analysis, and
X_i are indicators of environmental degradation.

The indicators used for the construction of the ID originally considered four aspects: one biological, two economic and one demographic aspect [23]. The present work raises another indicator addressing the technological aspect of degraded areas to be studied.

The biological indicator is associated with the vegetation of the regions studied. The first economic indicator focuses on the productivity of the fields while the second one, on the animals. The demographic indicator is related to the ability of the areas with crops and pastures to be capable of supporting the largest number of workers in agricultural activities [23]. Finally, the technological aspect approaches the expenditure on machinery and agricultural technologies used by the regions studied.

Data were calculated for 137 Brazilian mesoregions according to the division made by the Brazilian Institute of Geography and Statistics (IBGE), and from them it was calculated the average ID for the 26 states and the Federal District and for the 5 major regions that comprise the Brazilian territory. It must be stressed that the construction of an ID should involve an inherent knowledge of what would be the optimal levels for the construction of the index. Since this task is extremely difficult and could be affected by subjective actions of those in charge of that decision, it was adopted the criterion ranking, taking as basis 10% of themesoregions with best placements in each of the indicators. Therefore, it was considered 14 mesoregions, which served as a basis for the arithmetic estimation of each indicator, having its values taken as a reference for preservation. In other words, the further away the value found in a region in relation to the estimated average of an indicator, the greater the environmental degradation of the region in relation to the studied indicator [23].

From this, the indicators studied are defined as:

$\boldsymbol{COBV_k}$ = vegetation cover of the mesoregion, which represents the sum of the areas with native forests and cultivated, plus areas with perennial and temporary crops divided by the total area of the k-thmesoregion;
$\boldsymbol{COBV_{REF}}$ = average vegetation cover of the 14 mesoregions best positioned in relation to this indicator;
$\boldsymbol{VAVE_k}$ = value of crop production of the k-th Brazilian mesoregion divided by the sum of the areas with permanent and temporary crops;
$\boldsymbol{VAVE_{REF}}$ = average of this indicator in the 14 mesoregions better positioned in relation to it;
$\boldsymbol{VANI_k}$ = value of the k-th Brazilian mesoregion animal production divided by the total area of natural and cultivated pastures;
$\boldsymbol{VANI_{REF}}$ = average of this indicator in the 14 mesoregions better positioned in relation to it;
$\boldsymbol{MORU_k}$ = total number of work force in the rural area of the k-th mesoregion divided by the sum of the areas with crops and pastures;
$\boldsymbol{MORU_{REF}}$ = average of this indicator in the 14 mesoregions better positioned in relation to it;
$\boldsymbol{DETE_k}$ = value of expenditures on machinery and agricultural technologies, which represents the sum of the costs of fertilizers, pesticides, soil amendments, electricity and fuel divided by the total rural expenditure of the k-thmesoregion;
$\boldsymbol{D}$ 喧$\boldsymbol{TE_{REF}}$ = average of this indicator in the 14 mesoregions better positioned in relation to it;

Data were collected in the 2006 Agricultural Census and, based on the indicators mentioned, the structuring of these for the composition of the construction of IPD and the ID can be defined as follows, as proposed by [23]:

- DECOBV (X_{i1}) = 0, when $COBV_k \geq COBV_{REF}$;
- DECOBV (X_{i1}) = [1 – ($COBV_k$/ $COBV_{REF}$)]*100, in the other cases;
- DEVAVE (X_{i2}) = 0, when $VAVE_k \geq VAVE_{REF}$;
- DEVAVE (X_{i2}) = [1 – ($VAVE_k$/ $VAVE_{REF}$)]*100, in the other cases;
- DEVANI (X_{i3}) = 0, when $VANI_k \geq VANI_{REF}$;
- DEVANI (X_{i3}) = [1 – ($\_ANI_k$/ $VANI_{REF}$)]*100, in the other cases;
- DEMORU (X_{i4}) = 0, when $MORU_k \geq MORU_{REF}$;
- DEMORU (X_{i4}) = [1 – ($MORU_k$/ $MORU_{REF}$)]*100, in the other cases.
- DEDETE (X_{i5}) = 0, when $DETE_k \geq D\ 9TE_{REF}$;
- DEDETE (X_{i5}) = [1 – ($DETE_k$/ $DETE_{REF}$)]*100, in the other cases.

4 Results and Discussions

In order to analyze the descriptive statistics of the variables collected, the mean, standard deviation and the coefficient of variation were calculated, as shown in Table 1.

Table 1 – Descriptive statistics of variables

Variable	Mean	Standard Deviation	Coefficient of Variation
COBV	0,2348	0,1649	70,22%
VAVE	0,5852	0,2322	39,68%
VANI	0,8351	0,2452	29,37%
MORU	0,6062	0,2841	46,87%
DETE	0,4663	0,2121	45,49%

Source: Elaborated by the authors.

By analyzing the descriptive statistics of the variables studied, it appears that the coefficients of variation show some heterogeneity. However, all values present coefficients that are not so high, i.e. less than 50%, except for the COBV variable. This demonstrates that, despite the existing variation, there is a certain pattern of these variables throughout the national territory.

In order to check whether the variables are suitable for the factor analysis, the Bartlett test was conducted which showed a significance value of 0.000, and therefore, rejected the null hypothesis of equality of matrices, demonstrating the suitability of this type of analysis [26]. Another test performed to verify the adequacy of the factor analysis was the KMO test, which obtained a value of 0.568 and, thus, because it is greater than the value of 0.5, it indicates the viability to use factor analysis [17].

By using the principal components method and the Varimax orthogonal rotation method by factor analysis, it is clear that the six variables studied were grouped into two factors, which are able to explain 75.63% of the total variance of data.

Table 2 – Eigenvalues of the matrix and the explained variance of correlationsfor the cities of Brazilian mesoregions

Factor	Eigenvalue	Explained variance by factor (%)	Accumulated Variance (%)
1	2,59	41,90	41,90
2	1,18	33,73	75,63

Source: Elaborated by the authors.

From the definition of the number of factors, the factorial charges and the communalities associated with each one of them, they can be analyzed as shown in Table 3.

Table 3 – Factorial charges after orthogonal rotation and communalities

Variables	Factorial Charges F1	F2	Communalities
COBV	**0,736**	0,011	0,473
VAVE	**0,731**	0,168	0,654
VANI	**-0,567**	0,225	0,563
MORU	0,286	**0,757**	0,542
DETE	-0,340	**0,731**	0,650

Source: Elaborated by the authors
Note: Values in bold denote the largest factorial charge of the variable on one factor.

After splitting the factor analysis for the construction of the ID, a multiple regression analysis was carried out, with the IPD as a dependent variable and the other variables as independent. The values of each variable elasticity for the construction of ID are presented in Table 4:

Table 4 – Elasticity associated to the IPD for the construction of the ID

Factor	Elasticity
COBV	0,1148
VAVE	0,5841
VANI	0,3413
MORU	0,2502
DETE	0,2443

Source: Elaborated by the authors

From these values, there is the possibility to check the Index of Environmental Degradation of Brazilian mesoregions and their respective states and regions. Based on the Brazilian reality, from the mean of the mesoregions, the Degradation Index in the country was approximately of 57%. The value is justified by the representativeness of agriculture in the country and it shows that more than half of the national territory has environmental degradation, being from the government the task of promoting awareness among farmers as well as stimulating more sustainable techniques in the management of the environment [3].

Regarding the mesoregions with higher ID, this situation can be seen in Table 5:

Table 5 – Highest average ID of Brazilian mesoregions

Highest ID	**State**	**ID (%)**
North Amapá	AP	100,00
Wetlands South Mato Grosso	MS	100,00
Madeira-Guaporé	RO	94,21
South Roraima	RR	92,05
Northwest Goiás	GO	91,56
North Goiás	GO	90,82
Mucuri Valley	MG	88,47
South Amazonas	AM	86,73
North Roraima	RR	84,07
West of Tocantins	TO	83,92

Source: Elaborated by the authors.

Regarding the mesoregions with lower ID, this situation can be seen in Table 6:

Table 6 –Lower average ID of Brazilian mesoregions

Lower ID	**State**	**ID (%)**
Metropolitan of Rio de Janeiro	RJ	24,08
North Ceará	CE	21,04
Center East Rio Grande	RS	17,73
South Santa Catarina	SC	17,12
Northeast Rio Grande	RS	11,11
Metropolitan of Recife	PE	9,70
Itajaí Valley	SC	8,50
São Francisco Pernambuco	PE	7,10
Metropolitan of Sao Paulo	SP	3,98
Florianópolis	SC	0,00

Source: Elaborated by the authors.

From the analysis of Table 5 and Table 6, it is evident the existence of two mesoregions with 100% of environmental degradation. The northern region of Amapá might have its causes mainly related to development issues, thus supporting the hypothesis that environmental degradation is leveraged by lower levels of development. This relationship can also be confirmed by the observation that some of the mesoregions with lower ID are the most developed in Brazil in socioeconomic aspects. The other mesoregion with 100% of ID, the Wetlands of Mato Grosso do Sul, along with other regions with higher ID, confirm the premise that agricultural activities, predominantly in those areas, impacts on environmental degradation [9].

Analyzing the average rank of the degradation index of the 26 Brazilian states and the Federal District, as shown by Table 7, the following ranking of each region is presented:

Table 7 – Ranking of average ID of Brazilian states

State	**Position**	**Average ID**
Roraima	1º	88,06%
Rondônia	2º	88,05%
Amapá	3º	84,59%
Mato Grosso do Sul	4º	80,19%
Goiás	5º	80,14%
Tocantins	6º	78,40%
Amazonas	7º	75,97%
Maranhão	8º	72,46%
Piauí	9º	72,35%
Acre	10º	70,78%
Bahia	11º	69,62%
Mato Grosso	12º	68,20%
Pará	13º	67,13%
Rio Grande do Norte	14º	59,81%
Minas Gerais	15º	55,73%
Paraná	16º	55,48%
Rio de Janeiro	17º	55,19%
Paraíba	18º	54,64%
Espírito Santo	19º	53,23%
Sergipe	20º	50,13%
Distrito Federal	21º	44,65%
São Paulo	22º	43,92%
Ceará	23º	43,57%
Rio Grande do Sul	24º	42,31%
Alagoas	25º	39,76%
Pernambuco	26º	32,46%
Santa Catarina	27º	19,79%

Source: Elaborated by the authors.

Table 7 shows great differences in the ID of Brazilian states, demonstrating the heterogeneity of environmental degradation on the national scene. This is explained because, from the most degraded state to the least degraded, there is a difference of almost 70% compared to the index created.

Analyzing the states in the top ten positions regarding environmental degradation, there is a concentration in three Brazilian regions: North, Northeast and Midwest. In addition, all occupants of the first ten positions have rates higher than 70%. Limiting the analysis to those states situated in the most critical situations, i.e. with ID above 80%, there are five states in this situation, where the first three positions are situated in the Northern Region, namely, Roraima, Rondônia and Amapá, followed by the states of Mato Grosso do Sul and Goiás, both from the Midwest Region. These results confirm the premise that regions with higher levels of poverty are more degraded, which is especially prevalent in the three most degraded states of Northern Brazil [23, 13]. In addition, another hypothesis that environmental degradation is directly influenced by agricultural activities is also explicit when analyzing the other two states occupying the fourth and fifth positions in the ranking. These states are located in the Midwest of the country, a region where the economy is predominantly linked to agriculture, farming and extractive activities and thus contributes to the worsening of environmental degradation in these regions [12, 9, 21].

These results become more evident when the averages of environmental degradation in the five Brazilian regions are analyzed, as shown in Table 8.

Table 8 – Ranking of average ID in the Brazilian regions

State	**Position**	**Average ID**
North	1º	76,32%
Midwest	2º	73,81%
Northest	3º	55,57%
Southest	4º	50,58%
South	5º	42,16%

Source: Elaborated by the authors.

Table 8 shows the dominance of the North and Midwest regions in relation to environmental degradation of the Brazilian territory, as previously explained by the analysis of the states that compose these regions. It appears that the Northeast Region occupies an intermediate position regarding the levels of degradation. This region presented states with high and low Degradation Index. The states with reduced ID are from the most developed part of the region, while those with high ID are situated in the less developed regions, which are also impacted, in a greater magnitude, by Northeastern climatic aspects that contribute to the phenomenon of degradation and desertification [23].

The Southeast and South regions, being the most developed in Brazil, present the lowest ID and confirm the assumption that degradation is related to wealth, since the more developed regions have a greater concern regarding the environmental aspect [27]. In relation to the southern region, where there are state as Rio Grande do Sul for example, with great agricultural activity, it appears that the issue of regional socioeconomic development surpasses the participation and environmental impacts of activities related to agribusiness [36].

5 Conclusion

Environmental degradation is an issue of interest to many governments because of the economic and social impacts that this phenomenon has caused in society. In the Brazilian context, there is an emerging literature on the topic; however, it is not able to characterize the degradation in all national territory, focusing on just a few locations. Thus, this study proposed to analyze the environmental degradation, from an index, focusing in all the Brazilian reality.

When building the ID, it was evident that some regions have a very high standard of degradation, reaching in both cases the value of 100%. In relation to the national average, the value of 57% is worrying and shows that more than half of Brazil found itself degraded during the time period studied. In order to change this situation, there should be greater acts of public authorities as well as greater awareness of farmers.

Regarding the Brazilian states and its regions, it is observed that the North and Midwest of Brazil are in the most critical situation of this phenomenon. In the first region, the first hypothesis of the study is the justification for the higher levels of degradation, in other words, that less developed regions are degraded. However, in the Midwest Region, the second hypothesis of the study is confirmed, as the region has its economy based on agricultural activities, showing high levels of environmental degradation.

The study was limited to a specific period, so it was not possible to analyze the dynamics of degradation over time. Moreover, no other aspects of development of a region was highlighted, besides the environmental degradation, and the measurement of this phenomenon was limited to the collection of information through the index studied. Therefore, for future studies there is the possibility of studying environmental degradation over a longer period of time in order to check for a pattern on this phenomenon and to relate it to other aspects of development, such as, the economic and social aspects, Another opportunity is the use of more robust methodological procedures for the construction of an index, in order to assess the impacts of environmental degradation.

References:

[1] ALVES, S. R.; OLIVEIRA-SILVA, J. J. da. Avaliação de Ambientes contaminados por agrotóxicos. In: Frederico Peres; Josino Costa Moreira. (Org.). *É veneno ou é remédio?* Agrotóxicos, Saúde e Ambiente.

1ed. Rio de Janeiro: Editora Fiocruz, 2003, p. 137-156.

[2] AQUINO, C. M. S. de; ALMEIDA, J. A. P. de; OLIVEIRA, J. G. B. de. Estudo da Cobertura Vegetal/Uso da Terra nos Anos de 1987 e 2007 no Núcleo de Degradação/Desertificação de São Raimundo Nonato – Piauí. *Revista Ra'e Ga - O Espaço Geográfico em Análise*, Curitiba, v. 25, p. 252-278, 2012.

[3] ARAUJO, M. L. M. N. de; REINALDO, L. R. L. R.; SOUSA, J. da S.; ALMEIDA, P. G. de; ALVES, L. de S.; WANDERLEY, J. A. C. Impactos Ambientais nas Margens do Rio Piancó Causados pela Agropecuária. *Revista Brasileira de Gestão Ambiental*, Pombal, v. 4, n. 1, p. 13-33, 2010.

[4] BALSAN, R. Impactos Decorrentes da Modernização da Agricultura Brasileira. *CAMPO-TERRITÓRIO: Revista de Geografia Agrária*, Francisco Beltrão, v. 1, n. 2, p. 123-151, 2006.

[5] BASSAB, W. de O.; MIAZAKI, E. S.; ANDRADE, D. F. de. *Introdução à Análise de Agrupamentos*. São Paulo: Associação Brasileira de Estatística (ABE), 1990.

[6] BESSA JUNIOR, O.; MÜLLER, A. C. de P. Indicadores Ambientais Georreferenciados para a Área de Proteção Ambiental de Guaraqueçaba. *Revista Paranaense de Desenvolvimento*, Curitiba, n. 99, p. 105-119, 2000.

[7] BRAGA, T. M.; FREITAS, A. P. G. de; DUARTE, G. de S.; CAREPA-SOUZA, J. Índices de sustentabilidade municipal: o desafio de mensurar. *Nova Economia*, Belo Horizonte, v. 14, n. 3, p. 11-33, 2004.

[8] CARVALHO, S.P.; ALBUQUERQUE, H.N. Avaliação dos impactos ambientais no horto do Complexo Aluízio Campos. *Revista Brasileira de Informações Científicas*, Campina Grande, v. 2, n. 2, p. 1-16. 2011.

[9] CUNHA, N. R. da S.; LIMA, J. E. de; GOMES, M. F. de M.; BRAGA, M. J. A Intensidade da Exploração Agropecuária como Indicador da Degradação Ambiental na Região dos Cerrados, Brasil. *Revista de Economia e Sociologia Rural*, Piracicaba, SP, v. 46, n. 2, p. 291-323, 2008.

[10] EL KHALILI, A. *Commodities ambientais em missão de paz* – novo modelo econômico para a América Latina e o Caribe. São Paulo, SP: Nova Consciência, p. 271, 2009.

[11] ENGSTRÖM, R. et. al. Environmental assessment of Swedish agriculture. *Ecological Economics*, v. 60, n. 00, p. 550-563, 2007.

[12] FERNANDES, E. A.; CUNHA, N. R. da S.; SILVA, R. G. da. Degradação ambiental no estado de Minas Gerais. *Revista de Economia e Sociologia Rural*, Rio de Janeiro, v. 43, n. 1, p. 179-198, 2005.

[13] FINCO, M. V. A.; WAQUIL, P. D.; MATTOS, E. J. de. Evidências da relação entre pobreza e degradação ambiental no espaço rural do Rio Grande do Sul. *Ensaios FEE*, Porto Alegre, v. 25, p. 249-275, 2004.

[14] FOLHES, M. T. *Um Índice de Bem-estar Econômico Sustentável para o Ceará*. Dissertation in Development and Environment. Universidade Federal do Ceará. Fortaleza, 2000.

[15] GLIESSMAN, S. R. *Agroecologia: processos ecológicos em agricultura sustentável*. 3ª ed. Porto Alegre: Editora da UFRGS, 2005.

[16] GREENE, W. H. *Econometric analysis*.6 ed. New Jersey: Prentice Hall, 2008.

[17] HAIR, J. F JR..; BLACK, W. C.; BABIN, B. J.; ANDERSON, R. E.; TATHAM, R. L.;. *Análise Multivariada de Dados*. 6ª ed. Porto Alegre: Bookman, 2009.

[18] IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. *Censo Agropecuário de 2006*. Available in: <http://www.sidra.ibge.gov.br/bda/pesquisas/ca/default.asp?o=2&i=P>. Access in: 30 de jul., 2013.

[19] LADEIRA, W. J.; MAEHLER, A. E.; NASCIMENTO, L. F. M. do. Logística Reversa de Defensivos Agrícolas: fatores que influenciam na consciência ambiental de agricultores gaúchos e mineiros. *Revista de Economia e Sociologia Rural*, Piracicaba, v. 50, n. 1, p. 157-174, 2012.

[20] LEFF, E. Agroecologia e saber ambiental. *Agroecologia e Desenvolvimento Rural Sustentável*, Porto Alegre, v.3, n.1, 2002.

[21] LEITE, S. P.; SILVA, C. R. da; HENRIQUES, L. C. Impactos ambientais ocasionados pela agropecuária no Complexo Aluízio Campos. *Revista*

Brasileira de Informações Científicas, Campina Grande, v. 2, n. 2, p. 59-64, 2011.

[22] LEMOS, J.J.S. Desertification of Drylands in Northeast of Brazil, Riverside, Califórnia: *Economic Department University of California*, 1995.

[23] LEMOS, J.J.S. Níveis de Degradação no Nordeste Brasileiro. *Revista Econômica do Nordeste*, Fortaleza, v.32, n. 3, p. 406-429, 2001.

[24] LIRA, W. S.; CÂNDIDO, G. A. Análise dos Modelos de Indicadores no Contexto do Desenvolvimento Sustentável. *Perspectivas Contemporâneas*, Campo Mourão, v. 3, n. 1, p. 31-45, 2008.

[25] MICHELON, C. J.; CARLESSO, R.; PETRY, M. T.; DAVID, G. D.; SANTA, C. D. Qualidade física de solos irrigados do Estado do Rio Grande do Sul. *Ciência Rural*, Santa Maria, v. 37, n. 5, p. 1308-1315, 2007.

[26] MINGOTI, S. A. *Análise de dados através de métodos de Estatística Multivariada – uma abordagem aplicada*. Belo Horizonte: Editora UFMG, 2005.

[27] MOTTA, R. S. da. Desafios Ambientais da Economia Brasileira. *Texto para Discussão Nº 509*. Instituto de Pesquisa Econômica Aplicada, 1997.

[28] PAIS, P. S. M.; SILVA, F. de F.; FERREIRA, D. M. Degradação Ambiental no Estado da Bahia: uma aplicação da análise multivariada. *Revista Geonordeste*, São Cristóvão, a. XXIII, n.1, p. 1-21, 2012.

[29] PESTANA, M. H.; GAGEIRO, J. N. *Análise de dados para ciências sociais*. Lisboa: Sílabo, 2005.

[30] PINTO, N.G.M. *A Degradação Ambiental nos Municípios do Rio Grande do Sul e a Relação com os Fatores de Desenvolvimento Rural*. 2014. Dissertation in Business – Universidade Federal de Santa Maria. Santa Maria, RS.

[31] RAMPAZZO, L. *Metodologia científica: para alunos dos cursos de graduação e pós- graduação*. São Paulo: Loyola, 2002.

[32] RANIERI, S. B. L.; SPAROVEK, G.; SOUZA, M. P.; DOURADO NETO, D. Aplicação de Índice Comparativo na Avaliação do Risco de Degradação das Terras. *Revista Brasileira de Ciência do Solo*, Viçosa, v. 22, p. 751-760, 1998.

[33] REED, D.; SHENG, F. Macroeconomic Policies, Poverty and the Environment. *Macroeconomics for Sustainable Development Programme Office – World Wide Fund for Nature (WWF)*, Washington, 1997.

[34] RIGOTTO, R. M.; CARNEIRO, F. F.; MARINHO, A. M. C. P.; ROCHA, M. M.; FERREIRA, M. J. M.; PESSOA, V. M.; TEIXEIRA, A. C. de A.; SILVA, M, de L. V. da; BRAGA, L. de Q. V.; TEIXEIRA, M. M. O verde da economia no campo: desafios à pesquisa e às políticas públicas para a promoção da saúde no avanço da modernização agrícola. *Revista Ciência & Saúde Coletiva*, Rio de Janeiro, v. 17, n. 6, p. 1533-1542, 2012.

[35] RODRIGUES, W. Valoração Econômica dos Impactos Ambientais de Tecnologias de Plantio em Região de Cerrados. *Revista de Economia e Sociologia Rural*, Rio de Janeiro, v. 43, n. 01, p. 135-153, 2005.

[36] ROSSATO, M. V. *Qualidade ambiental e qualidade de vida nos municípios do Estado do Rio Grande do Sul*. Thesis in Applied Economics. Universidade Federal de Viçosa. Viçosa, 2006.

[37] RUFINO, C. R. *Avaliação da qualidade ambiental do município de Tubarão (SC) através do uso de indicadores ambientais*. Dissertation in Production Engineering. Universidade Federal de Santa Catarina. Florianópolis, 2002.

[38] SAMPAIO, E. V. de S. B.; ARAÚJO, M. S. B.; SAMPAIO, Y. S. B. Impactos ambientais da agricultura no processo de desertificação no Nordeste do Brasil. *Revista de Geografia*, Recife, v. 22, n. 1, p. 93-113, 2005.

[39] SANTOS, F. P. dos; CHALUB-MARTINS, L. Agroecologia, consumo sustentável e aprendizado coletivo no Brasil. *Educação e Pesquisa*, São Paulo, v. 38, n. 2, p. 469-483, 2012.

[40] SILVA, A. W. L. da; SELIG, P. M.; MORALES, A. B. T. Indicadores de Sustentabilidade em Processos de Avaliação Ambiental Estratégica. *Ambiente & Sociedade*, São Paulo, v. XV, n. 3, p. 75-96, 2012.

[41] SILVA, R. G. da; RIBEIRO, C. G. Análise da Degradação Ambiental na Amazônia Ocidental: um Estudo de Caso dos Municípios do Acre. *Revista de*

Economia e Sociologia Rural, Rio de Janeiro, v. 42, n. 1, p. 91-110, 2004.

[42] STEEG, J. A. V. de; SPAROVEK, G.; RANIEN, S. B. L.; MAULE, R. F.; COOPER, M.; DOURADO NETO, D.; ALVES, M. C. Environmental Impacto f the Brazilian Agrarian Reform Process from 1985 to 2001. *Scientia Agricola Journal*, Piracicaba, v. 63, n. 2, p. 176-183, 2006.

[43] VIANA, D. de L.; ROCHA, D. R. W.; CORDEIRO, M. F. R.; SILVA, J. F. da. Avaliação dos Impactos Ocasionados na Biodiversidade pela Atividade de Pedreira no Complexo Aluizio Campos. Revista Brasileira de Informações Científicas, Campina Grande, v. 2, n. 2, p. 45-58, 2011.