Mapping of Environmental Degradation in Regions and States of Brazil

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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

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;
$\boldsymbol{D}$ 喤$\boldsymbol{TE_{REF}}$ = 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	Factorial Charges 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