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Neutrosophic Analysis of the Irrational Exploitation of Natural Resources

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Abstract: Natural resources are used by human beings to satisfy their subsistence needs. In this sense, the conservation of the environment requires a system of social, socioeconomic, and technical-productive measures, aimed at the rational use of natural resources, the conservation of natural complexes, as well as the defense of the environment against pollution and degradation. The objective of this study is to analyze the factors that influence the irresponsible use of natural resources through neutrosophic statistics. From the results, it was obtained that a proposal to reform the environmental legislation should be recommended to control and avoid the overexploitation of natural resources, in addition to achieving environmental education in the population and thus acquiring responsible ecological behavior in society.

Keywords: Environment, natural resources, conservation, ecological behavior.

1. Introduction

The conservation of natural resources is an essential task to move towards a more sustainable economy that takes into account their availability. Life depends heavily on natural resources. Everything is made of materials that, in one way or another, have been extracted from nature. Natural resources are the elements and forces of nature that man can use and take advantage of. They are those goods that nature provides and that are used by people either to consume them directly or to be used in some production process. These represent sources of wealth for economic exploitation. They can be biotic or abiotic and are classified into renewable and non-renewable resources.

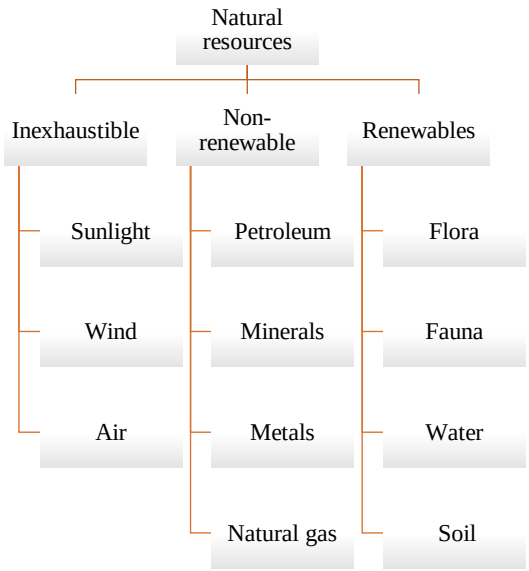

Figure 1: Natural resources. Source: own elaboration

The exploitation of non-renewable natural resources has caused the destruction of the environment. A perhaps

irreversible environmental impact if nothing is done about it so as not to continue with this type of activity that is harmful to nature. In environmental legislation, restoration mechanisms should be specified, and strict and necessary measures should be taken to prevent companies from continuing to destroy the environment itself.

Among the renewable resources are the flora and fauna where there is a very close dependence, based on natural laws that govern the structure and functions of the associations of living beings. Feeding relationships, or trophic relationships, determine the so-called food chains, in which herbivorous animals constitute the basic food for other groups of animals that, in turn, will serve as food for others. This has the consequence that the decrease in number or the disappearance of one of these links in the chain, due to natural causes or the influence of man, endangers the entire system. That is, the balance that characterizes the relationships between the biotic and abiotic environment of nature is broken.

Currently, the development of society is equally attacking the species of animals and plants, in those countries subject to the excessive exploitation of natural resources. The development of industry, which pollutes the environment with its waste, also affects the natural environment and, consequently, the living systems that inhabit it. This leads to reflecting on the care that man must have when exploiting the resources that nature provides.

Ecuador recognizes and guarantees constitutional rights to nature: full respect for its existence, and restoration. Therefore, it is necessary to fight for the protection of all the species and ecosystems that coexist in it, to live in harmony with nature and not unbalance everything that has meant millions of years of evolution, but that can be demolished in decades of irrational human exploitation. The supreme norm establishes state and citizen duties, framed in respect for nature, the Ecuadorian Constitution, provides for its application and interpretation according to the principles of the supreme norm [1, 2].

It is a customary practice to locate industries and human settlements on the banks of water currents, to use said liquid, and, at the same time, dump the waste from the industrial process and human activity. This results in the contamination of water sources and the loss of large volumes of this resource. Currently, many countries that are concerned about conservation, prohibit this practice and require the treatment of waste to bring it to admissible measures for human health.

The responsible use of natural resources guarantees a healthier and more balanced environment. It is necessary to make people aware of the negative effects that the planet suffers when excessively using its resources. Humanity has always taken advantage of the natural resources in its environment to make life easier and better. And that is the exploitation of natural resources [3].

When talking about exploitation, reference is made to how benefits are extracted from nature to be used in a market economy. Because, although the Ministry of the Environment of Ecuador, exercises the governing role of environmental management and its function is to guarantee a healthy and ecologically balanced environment to make the country a nation that conserves and sustainably uses its biodiversity. In addition to maintaining and improving environmental quality and seeking and promoting sustainable development and social justice, it is not enough because the exploitation of the resources that nature provides must be planned, in order to anticipate problems and seek alternatives.

Human beings are part of the ecosystem and infer or cause environmental problems through their behavior, depending on the degree of knowledge, respect, and responsibility they have towards nature. The concept of environment has almost always been associated exclusively with natural systems, with the protection and conservation of ecosystems, perceived as the unique relationships between biotic and abiotic factors, without analysis or reflection on the incidence of sociocultural, political, and economic aspects in the dynamics of these natural systems.

In the case of Ecuador, due to its geographical location, it enjoys great natural wealth and among its natural resources, it contains water resources, forestry, soil, fauna, flora, etc. These are used by Ecuadorians as a source of work and subsistence, which promotes the economy and other social aspects. The production of wood is an important economic source for the country, but the deforestation suffered by the great demand for wood causes a degenerative process to take place in the area.

In the country, in addition to identifying a positive increase in its economic variables in recent years, concern for the environment has intensified with not very clear results on the reduction of pollution and the increase in levels of degradation. It is not enough to protect the environment as a place in which human beings live, it is necessary to promote the sustainable development of the environment to guarantee the efficient use of these and future generations.

The environmental degradation with greater notoriety is anthropic. It generally originates because a series of economic agents behave in such a way that, by solving certain particular problems, they generate environmental deterioration as a consequence. The solution to the problem likely involves designing a series of measures, of all kinds, aimed at modifying this behavior. Natural resources are depleted due to a practice of exploitation governed by economic, productive, and extractive logic and rationality, which also generates negative environmental and social impacts, of a local, regional and global nature, in the worst case irreversible. The action of human beings on the environment has produced a planetary environmental emergency [4], [17], [20].

In Ecuador, the social development of communities influences environmental deterioration. This is described by internal disparities between the development of the provinces and the gross national income. No development

model is considered as such if it does not link the community in its efforts, so it is important to link the endogenous development of the communities in order to favor economically and socially the most unprotected.

On the other hand, the technological development that is unmatched by others, allowed a substantial improvement in the quality and life expectancies of the human being, compared to pre-industrial times. But it also brought with it pollution, overexploitation, and ecological destruction. [16]

Consequences of overexploitation:

- Resource depletion. The extinction of species, the rapid exhaustion of mines, or the end of exploitable surfaces weaken the industry and lead to a crisis of raw materials.
- Environmental destruction. The destruction of natural habitats affects the quality of life of numerous species, leading to extinction and the impoverishment of global biodiversity.
- Pollution. Overexploitation releases a greater amount of toxic, radioactive, or ecological balance-modifying waste, without giving the ecosystem time to deal with them or recover from its impact.
- Socioeconomic crisis. The imbalance of the extraction mechanisms usually leads to a raw material crisis and, therefore, to imbalances in the international market, now that the economy is globalizing. This translates into poverty and social and economic damage for the weakest countries.
- Increased global warming and climate change.

The care of natural resources is transcendental, not only because they are the basis of modern productive societies, but also because they are an essential part of nature and are what allows the existence of living beings on planet Earth. Human activity exploits them intensely, so there must be regulations in the different territories to control and prevent their overexploitation. The environmental impact caused by human action is even greater, and has irreversible consequences, because non-renewable resources are exploited, which at a given moment can end, and even worse, without being restored or rehabilitated. [22], [23], [24]

This study aims to analyze the factors that influence the irresponsible use of natural resources, to mitigate or eliminate the environmental impact caused by their irrational exploitation. As well as to propose a reform to the environmental legislation to implement the mechanisms of restoration to nature.

2 Materials and methods

2.1 Neutrosophic Statistics

Neutrosophic Statistics was founded by Prof. Florentin Smarandache who developed it in 2014 introducing Neutrosophic Descriptive Statistics (NDS). Later, Prof. Muhammad Aslam, from King Abdulaziz University, Saudi Arabia, founded Neutrosophic Inferential Statistics (NIS), Neutrosophic Applied Statistics (NAS), and Neutrosophic Statistical Quality Control (NSQC) in 2018.

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of event E is the probability that event E occurs [5], [18], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3+.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$NP(x) = (T(x), I(x), F(x))$,

Where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not occur, and I(x) represents the undetermined or unknown probability of value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, neutrosophic probability distribution, neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and the methods to analyze them [6], [19].

While Classical Statistics deals with determined data and determined inference methods, Neutrosophic Statistics deals with indeterminate data, that is, data that has some degree of indeterminacy (unclear, vague, partially unknown, contradictory, incomplete, etc.), and of indeterminate inference methods that also contain degrees of indeterminacy (for example, instead of arguments and crisp values for probability distributions, graphs, diagrams, algorithms, functions, etc. may have inaccurate or ambiguous arguments and values)

Neutrosophic Statistics is also a generalization of Interval Statistics because while Interval Statistics is based on Interval Analysis, Neutrosophic Statistics is based on Set Analysis (understanding by such all types of sets, not just intervals).

If all the data and methods of inference are determined, then Neutrosophic Statistics coincides with Classical Statistics. Since in our world, we have more indeterminate than determined data, more neutrosophic than classical statistical procedures are needed [7,8, 14].

Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns.

Finally, the Neutrosophic Logic [9], the Neutrosophic Sets, and the Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference for study in full development.

Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data [10, 11, 13, 21, 22, 23, 24].

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers, while "I" is the indeterminacy part of the neutrosophic number N.

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represents the lower and correspondingly higher level that the studied variable can reach, in an indeterminate interval. Following the neutrosophic mean of the variable by formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il},\ \ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu},\ n_N \in [n_l, n_u], \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS) it can be calculated as follows

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N\begin{bmatrix} \min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix} \\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\end{bmatrix}, I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by:

$$\boldsymbol{S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in [S_L^2, S_U^2]} \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV, the more consistent the performance of the factor is than that of the other factors. The NCV can be calculated as follows [12, 13].

$$\boldsymbol{CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \in [CV_L, CV_U]} \tag{5}$$

3 Results

Application of the techniques outlined above, for the analysis of the factors that influence the irresponsible use of natural resources. Due to the complexity and indeterminacy of the data, it was decided to apply neutrosophic statistics for the modeling of the analyzed variable.

From the processing of the information and the consensus of the experts, the factors that most influence the irrational exploitation of natural resources and the variable to be modeled were determined (Table 1).

Factors that affect the irrational exploitation of natural resources	**Scale**	**Traits**	**Category of incidence**
Industrial activity	[0 ; 5]	Insufficient or null development of production techniques that are not harmful to the environment.	0 – They do not constitute a danger to natural resources. 1 – Likely to affect in the long term. 2 – It affects on a smaller scale. 3 – It is considered an affectation.
Poverty	[0 ; 5]	Insufficient income that forces a certain number of people to participate in environmental deterioration.	
Lack of regulations	[0 ; 5]	Low level of implementation of rules and regulations by governing and control	

		bodies in the fight to conserve natural resources.	4 – It is considered an affectation with an impact in the region.
Economic needs of the community.	[0 ; 5]	Insufficient income levels and internal differences between the development of communities.	5 – It constitutes a threat to the ecosystem.
Minimal existence of educational tools.	[0 ; 5]	Lack of reorientation of environmental education.	

Table 1. Incidence category for each factor. Source: own elaboration

It was decided to codify the factors and thus make the results viable, for the modeling of neutrosophic statistics (Figure 1). Variable analyzed: irrational exploitation of natural resources, for a sample of n=130 for each factor (f).

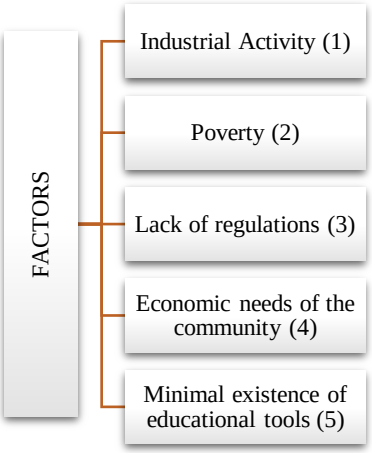

Figure2: Determining factors in the irrational exploitation of natural resources. Source: Own elaboration.

For the development of the statistical study, the neutrosophic frequencies of the determining factors in the irrational exploitation of natural resources are analyzed. For each factor, an incidence score is analyzed, which makes up the set of affectations to anticipate problems and look for alternatives.

Days	Neutrosophic frequencies				
	1	**2**	**3**	**4**	**5**
1	[2 , 5]	[0 , 0]	[1, 3]	[0 , 2]	[1 , 1]
2	[1, 3]	[0 , 0]	[0 , 3]	[0 , 0]	[1 , 2]
3	[0 , 3]	[2, 4]	[2 , 5]	[1, 4]	[1, 4]
4	[1, 1]	[2, 4]	[1, 3]	[0 , 2]	[1 , 1]
5	[0 , 1]	[0 , 3]	[0 , 3]	[1 , 2]	[1 , 2]
6	[1 , 2]	[2, 4]	[1, 1]	[0 , 2]	[1 , 1]
7	[0 , 1]	[2 , 2]	[0 , 1]	[2 , 2]	[1 , 2]
8	[1 , 2]	[1, 4]	[2 , 2]	[1 , 1]	[0 , 1]
9	[2, 3]	[1 , 2]	[1, 4]	[0 , 1]	[1 , 2]
10	[2 , 5]	[1, 4]	[0 , 2]	[0 , 0]	[2, 3]
11	[1, 4]	[2, 3]	[2, 4]	[2 , 5]	[2, 3]
12	[1, 4]	[0 , 0]	[2 , 5]	[2 , 5]	[1 , 2]
13	[2 , 2]	[1 , 2]	[2, 4]	[2, 3]	[1, 3]
14	[1, 4]	[2, 4]	[1, 3]	[0 , 1]	[1, 4]
15	[1 , 2]	[1 , 2]	[2, 4]	[1 , 2]	[2 , 5]
16	[1 , 2]	[1 , 1]	[2, 4]	[0 , 0]	[1, 4]

17	[2, 4]	[0 , 0]	[0 , 3]	[1, 4]	[1 , 1]
18	[0 , 0]	[2, 4]	[2, 4]	[2, 4]	[0 , 1]
19	[2, 3]	[1, 3]	[1 , 1]	[1 , 2]	[2 , 5]
20	[2 , 5]	[1, 3]	[0 , 2]	[0 , 0]	[2 , 2]
21	[2, 4]	[2 , 2]	[2, 3]	[0 , 0]	[0 , 2]
22	[2 , 2]	[0 , 0]	[1, 3]	[0 , 0]	[2 , 5]
23	[2 , 5]	[0 , 0]	[1, 4]	[0 , 3]	[0 , 1]
24	[0 , 1]	[1, 3]	[1, 4]	[1 , 1]	[0 , 3]
25	[0 , 3]	[0 , 2]	[2 , 2]	[0 , 2]	[0 , 0]
26	[2, 4]	[1 , 1]	[0 , 0]	[0 , 1]	[2 , 5]
27	[2, 4]	[0 , 3]	[1, 4]	[1 , 2]	[2, 3]
28	[2, 3]	[2 , 2]	[1 , 2]	[1, 4]	[0 , 3]
29	[1, 3]	[2, 3]	[2 , 2]	[2, 3]	[0 , 0]
30	[1 , 2]	[1, 4]	[2, 3]	[0 , 0]	[2, 3]
0-130	[132, 366]	[142, 343]	[153, 361]	[110, 287]	[137, 352]

Table 2. Neutrosophic frequencies of the factors. Source: own elaboration

Table 2 analyzed the neutrosophic frequencies of occurrence of the determining factors in the irrational exploitation of natural resources, for 130 days, with an occurrence level of [0; 5] for each factor per day with a total uncertainty level of 1=234, 2=201, 3=208, 4=177, 5=215, and a representativeness level of [57.62%; 63.93%], on the days that 5 affectations per factor are registered, with an incidence of 60% in terms of poverty. The poor move to areas of high diversity to acquire the resources they need to meet social demands in an unsustainable way, without implementing restoration strategies based on natural regeneration.

From the results of the affectations of the design (Table 3), it will be possible to understand which factor implies a representative mean $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic measures are calculated, and for the study of the variations of the affectations, the values of the standard deviation neutrosophic $S_N \in [S_L; S_U]$. To determine which affectation requires a greater incidence in the irrational exploitation of natural resources, the values $CV_N \in [CV_L\ ;\ CV_U]$ are calculated.

Factors	$\bar{x}_N$	S_N	CV_N
Industrial activity	[1,015 ; 2,815]	[0.423 ; 2024]	[0.417 ; 0.719]
Poverty	[1,092 ; 2,638]	[0.433 ; 2001]	[0.397 ; 0.759]
Lack of regulations	[1,177 ; 2,777]	[0.419 ; 1826]	[0.356 ; 0.658]
Economic needs of the community.	[0.846 ; 2,208]	[0.439 ; 2,075]	[0.519 ; 0.94]
Minimal existence of educational tools.	[1,054 ; 2,708]	[0.445 ; 2,167]	[0.422 ; 0.8]

Table 3. Neutrosophic statistical analysis of incidents in the irrational exploitation of natural resources. Source: own elaboration.

It was determined that factors 3 and 1, have higher average values that affect the other factors (Table 3). Therefore, they are, on average, the ones that incur the most in the excessive use of natural resources and the conservation of the environment. On the other hand, the value of CV_{Nb} in 3 is lower than the rest. Therefore, its result has a more solid, coherent, and exact impact than the other factors when evaluating indeterminacy, in the efficient use and care of the environment.

Factors	$\bar{x}_N$	Y_N	CV_N
1	1,015 + 2,815 I	0.423 + 2.024 I	0.417 + 0.719 I
2	1,092 + 2,638 I	0.433 + 2.001 I	0.397 + 0.759 I
3	1,177 + 2,777 I	0.419 + 1.826 I	0.356 + 0.658 I
4	0.846 + 2.208 I	0.439 + 2.075 I	0.519 + 0.94 I
5	1,054 + 2,708 I	0.445 + 2.167 I	0.422 + 0.8I

Table 4. neutrosophic forms. Source: Own elaboration

Factors	$\bar{x}_N$	Y_N	CV_N
1	I ∈ [0.0; 63.9]	I ∈ [0.0; 79.1]	I ∈ [0.0; 42.0]
2	I ∈ [0.0; 58.6]	I ∈ [0.0; 78.4]	I ∈ [0.0; 47.7]
3	I ∈ [0.0; 57.6]	I ∈ [0.0; 77.1]	I ∈ [0.0; 45.9]
4	I ∈ [0.0; 61.7]	I ∈ [0.0; 78.8]	I ∈ [0.0; 44.8]
5	I ∈ [0.0; 61.1]	I ∈ [0.0; 79.5]	I ∈ [0.0; 47.3]

Table 5. Uncertainty measures. Source: own elaboration.

The associated referent uncertainty measure is calculated, $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, $S_N \in [S_L; S_U]$ y $CV_N \in [CV_L\ ;\ CV_U]$ and in the form of neutrosophic numbers (comparative analysis. Tables 4 and 5). The results show that the values range from 0.356 to 0.658, with the measure of indeterminacy generating a negative impact on the lack of regulations regarding the a45.9. Application of regulations that guarantee supervised exploitation and the conservation of the environment.

Man must study the relationships and laws that determine the balance in nature and become its maximum protector, since, in a general sense, all the effects suffered by the natural environment have repercussions on it in one way or another. The actions that are carried out to promote the sustainable and economic development of Ecuador must be taken into account as government policies to guarantee the economic and social sustainability of the citizenry. It is a duty to take care of resources, as well as to create awareness of the role they play in the life of all living beings. [14]

Reorient education towards sustainable development. Therefore, educational approaches aimed at promoting the development of communities, which can act in favor of the establishment of development and environmental models, should be incorporated into environmental education. Awareness must be generalized to the entire population because the responsible use of what is obtained from nature is important in the daily life of all people. Environmental care and the efficient use of natural resources is a task that involves the interest of all humanity. In the country, promoting the efficient use of environmental resources through research studies is of great importance since they promote the balanced use of the satisfaction of human needs in the present. Care and respect for the environment, as well as for the diversity of life and natural resources, are the guarantee of being able to satisfy the environmental needs of future generations. [15]

Conclusion

Human beings use elements obtained from the natural environment to supply basic needs. Other resources are used for the production of tools and products in various industries. This type of activity witnessed a great increase as a result of the industrial revolution and subsequent technological revolutions that allowed the emergence of contemporary society. The new consumer society needed to mass-produce its goods, which required constant raw materials in large quantities. All this use without measure has a negative impact on ecosystems and results in global warming, the clearing of forests, and the reduction of species of flora and fauna.

The analysis of the neutrosophic statistics arrived at a level of indeterminacy of 45.9% that the lack of regulations is the affected factor since there are legal gaps in determining compliance with the laws and the levels to achieve natural renewal. This has an inversely proportional influence with respect to the other factors so that if this factor decreases, the other factors increase and the exploitation suffered by natural resources would be reversible through the conservation of the environment.

All of the above leads to the conclusion that it is of great importance to reform the Environmental Management Law. In this, actions must be taken such as planning the exploitation of the resources that nature provides, in order to anticipate problems and look for alternatives. Regulate the application of good environmental practices, as well as decrees that sanction those who do not have an environmental license. The State must undertake policies that guarantee the preservation of the environment since the intensive use of natural resources translates into a decrease in income, which condemns a country to poverty.

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