SYSTEMIC ENVIRONMENTAL IMPACT ASSESSMENT

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ABSTRACT

The objective of this paper is to present the methodology of Systemic Environmental Impact Assessment (SEIA), developed by the undersigned through the PIGA Group of Research in Politics, Information and Environmental Management of the National University of Colombia, as a unique and innovative proposal for the protection of the environment, through the design, development and use of systematic tools, which allow a qualitative leap, both in the methods of evaluation of impacts by project promoters, and in licensing and monitoring processes by the environmental authority. The SEIA methodology is based on the process of "Systemic parametrization of the environmental dimension", which allows the collection, organization, systematization, aggregation and proper storing of the environmental information of a project, program, plan or policy, as an input basic for the design and development of a holistic, integral and systemic algorithm that optimizes the methodologies of environmental impact assessment, in the public-institutional, economic, social and environmental context of each country.

Keywords: monitoring, evaluation, impacts, environmental management.

1 INTRODUCTION

Many developing countries, such as Colombia, possess great natural wealth in ecosystem and anthropic goods and services, which positions them in a privileged way in the international context. However, the processes of globalization and the market rules imposed by the current model of world economic development lead these countries (with the consent of their States) to base their development almost exclusively on the exploitation of their Non-Renewable Natural Resources (NRNR), most of the times through foreign capital and multinational companies, with very few considerations about the institutional, economic, social and environmental impacts that their activity generates.

To counteract (or facilitate?) the above, at least as far as environmental impacts are concerned, since 1993 many of these countries have been implementing "Environmental Licensing" processes, as is the case in Colombia, where through the National Environmental System (NES), the Environmental License was established in Title VIII of Law 99 of 1993 as a mandatory requirement for "the execution of works, the establishment of industries or the development of any activity, which in accordance with the law and regulations, may cause serious deterioration to renewable natural resources or the environment or introduce considerable or notorious modifications to the landscape..." [1] and defined as "the authorization granted by the competent environmental authority for the execution of a work or activity, subject to compliance by the beneficiary of the license of the requirements that it establishes in relation to prevention, mitigation, correction, compensation and management of the environmental effects of the authorized work or activity" [1].

The achievement of the environmental license imposes on companies promoting projects or activities, the submission to a series of requirements that involve, among others:

- Evaluate the environmental impacts of the project to be carried out, in order to formulate the environmental management plan to control the identified impacts.
- Guarantee the economic resources and the assurance required for the effective implementation of the environmental management plan.

- Effectively execute the environmental management plan.
- Fully comply with environmental regulations.

Likewise, it imposes on the competent environmental authority, that is, on the State, to develop and maintain the adequate environmental licensing procedures for:

- Guide the promotion companies through terms of reference in carrying out environmental impact assessments in their projects or activities.
- Evaluate the technical and legal compliance of said environmental impact assessments and granting or not of environmental licenses and permits.
- Follow up on the licensed projects.
- Apply the corresponding sanctioning regime for non-compliance.

In spite of the multiple advances achieved in the process of environmental licensing and regardless of political and macroeconomic considerations that could be contrary to the mission of society and particularly of the States to protect the environment, in general terms there are still some problems of a technical and management nature that needs to be addressed, particularly those related to the environmental impact assessment, which is the "heart itself" of the environmental licensing process, such as [2]:

- From the State (low institutional capacity to exercise environmental authority):
  - Inappropriate regulatory framework and terms of reference.
  - Disarticulation of environmental licensing with territorial ordering.
  - Generalized disarticulation within the NES.
- From the Companies (low quality of the Environmental Studies):
  - Low quality of the environmental information used.
  - Little or no technical development in methodologies and environmental impact assessment procedures used
- From Civil Society (little or no social participation)

This problem prevents the impact evaluation from being a holistic, integral and systemic process, which is, involving the entire environment of the area of influence of the projects and guaranteeing the incorporation of existing causal relationships between anthropic actions and environment. As a consequence of all the above, it is worth asking:

- How to move towards sustainable development with minimal impact on the environment?
- How to provide the State with enough institutional capacity for the proper exercise of environmental authority?
- How to articulate impact assessment and environmental licensing to the territorial environmental order of the country?

The answer to these questions can be found in the process of Systemic Environmental Impact Assessment (SEIA) that is proposed here, as a unique and innovative proposal for the protection of the environment, which will allow a qualitative leap in the methods of impact evaluation by part of the promoter companies, as in the licensing and monitoring processes by the environmental authority.

2 CONCEPTUAL AND METHODOLOGICAL APPROACH

The conceptual foundation of the SEIA is the process of "Systemic Parametrization of the Environmental Dimension" [3], which allows to have environmental information duly collected, organized, systematized, aggregated and stored, through the State-Pressure-Management (SPM) matrix and its indicative configuration over time through Environmental Information Baselines (EIBL), as described below.

2.1 State-Pressure-Management (SPM) matrix

The State-Pressure-Management (SPM) matrix is designed and structured as a logical tool for environmental integration, which, in addition to envisaging causal relationships in the general spectrum of environmental information, facilitates its collection, organization, aggregation, systematization, storage and disposal, within a framework of environmental integration based on the interaction and interdependence of the ecosystem and culture [3].

Its entries are related to the State of the goods and/or ecosystem and cultural services; with anthropic Pressure due to the demand for ecosystem goods and services, due to solid, liquid and gaseous wastes, and due to environmental impacts; and finally, with environmental Management carried out by the public sector, the economic sector and the civil society to minimize pressure and optimize environmental status, as shown in Table 1.

2.2 Environmental Information Baselines (EIBL)

The environmental information may be registered spatially and temporally through the configuration of Environmental Information Baselines (EIBL), generically defined as "spatio-temporal scheme of organization and systematization of SPM information that makes it possible to characterize the territorial or sectoral environmental dimension, for different periods of time" [3].

The EIBL are indicatively configured according to the state-pressure-management scheme for each period of time in the ecosystem-culture interaction and interdependence, as outlined in Fig. 1.

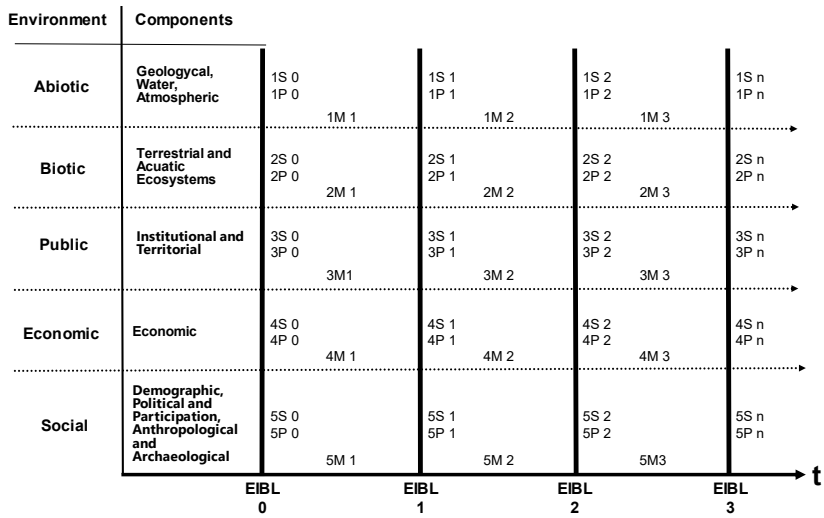

Figure 1: Environmental Information Baselines (EIBL). *(Source: [3].)*

Table 1: State-Pressure-Management (SPM) matrix. *(Source: [3].)*

ENVIRONMENTAL DIMENSION													
Environment		Environmental Components	Environmental Subcomponents	Environmental State (S)			Anthropic Pressure (P)			Environmental management (M)		
				k quantity	q quality	y availability	d demand	r waste	i impacts	PS public sector	ES economic sector	CS civil society
Ecosystems	Abiotic Environment	Geological	Regional and local geology	1S						PS	ES	CS
			Geomorphology	2S					2i			
			Geotechnics	3S					3i			
			Soils	4k	4q	4y	4d	4r	4i			
			Non-Renewable Natural Resources (NRNR)	5k	5q	5y	5d	5r	5i			
		Water	Surface water	6k	6q	6y	6d	6r	6i			
			Groundwater	7k	7q	7y	7d	7r	7i			
		Atmospheric	Weather	8S					8i			
			Air	9S					9i			
			Noise	10S					10i			
	Biotic Environment	Terrestrial ecosystems	Terrestrial flora	11k	11q	11y	11d	17g	11i			
			Terrestrial fauna	12k	12q	12y	12d		12i			
		Aquatic ecosystems	Aquatic flora	13k	13q	13y	13d		13i			
			Aquatic fauna	14k	14q	14y	14d		14i			
Culture	Public Environment	Public - institutional	Institutional framework for public management	15S					15i			
			Institutional framework for environmental management	16S					16i			
		Public territorial	Public space in urban and rural settlements	17S					17i			
			Infrastructure of roads and transport	18S					18i			
			Public services	19S					19i			
			Social services	20S					20i			
			Poles and trends of territorial development	21S					21i			
	Economic Environment	Economic	Property structure	22S					24i			
			Productive structure	23S					25i			
			Commercial structure	24S					24i			
			Working market	25S					25i			
			Poles and trends of sectorial development	26S					26i			
	Social Environment	Demographic	Demographic characterization population groups	27S					27i			
			Population dynamics and demographic trends	28S					28i			
			Standard of living of the population	29S					29i			
		Political and participation	Political aspects, community organization and participation mechanisms	30S					30i			
			Social perception of the sector, sub-sector, program or project	31S					31i			
		Anthropological and archaeological	Symbolic world or social imaginary, archaeological heritage	32S					32i			

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2.3 Methodology of Systemic Environmental Impact Assessment (SEIA)

Conceptually, the environmental impacts in the area of influence of a Project, Program, Plan or Policy (PPPP) can be defined as the difference between the State-Pressure-Management (SPM) conditions with PPPP (wp) and without PPPP (op), that is, as the difference between the SPM Matrix (wp) and the SPM Matrix (op), or also, as the difference between the EIBL with PPPP (wp) and without PPPP (op), as expressed in the eqns (1) and (2).

$$\text{Environmental Impacts} = \text{SPM Matrix (wp)} - \text{SPM Matrix (op)}, \quad (1)$$

$$\text{Environmental Impacts} = \text{EIBL (wp)} - \text{EIBL (op)}. \quad (2)$$

Theoretically, the Total Environmental Impact (TEI) of a project or alternative (k) is determined by eqn (3) [4]:

$$TEI_k = \sum_{i=1}^{i=n} P_i \,.\, V_{ij}\,, \quad (3)$$

where:

- P_i = Weighted Environmental Importance. Varies between (0–1000)
- $|V_{ij}|$ = Net Impact value received (± 1). It is calculated by means of eqn (4):
  - $$|V_{ij}| = \left[\frac{|I_{ij}|}{máx(|I_{ij}|)} \;.\; \left(NES_{ij}\right)^2\right]^{1/3}. \quad (4)$$
- I_{ij} = Intrinsic importance. It is calculated by means of eqn (5), through a panel of experts that performs the intrinsic characteristics with the help of Table 2.

$$I_{ij} = NA_{ij}\left(3IN_{ij} + 2EX_{ij} + MO_{ij} + PS_{ij} + PR_{ij} + RV_{ij} + SI_{ij} + AC_{ij} + CE_{ij} + RC_{ij}\right) \quad (5)$$

Table 2: Qualitative assessment guide. *(Source: [2]. Adapted from [4].)*

CARACTERÍSTICA		DESCRIPCIÓN	VALORACIÓN CUALITATIVA	
I	IMPORTANCIA INTRÍNSECA	Medida cualitativa del impacto en términos de sus características intrínsecas.	Irrelevante	0 - 25
			Moderado	26 - 50
			Severo	51 - 75
			Crítico	76 - 100
NA	NATURALEZA	Carácter beneficioso o perjudicial del impacto. Puede generar mejoramientos o deterioros en el medio ambiente.	Mejoramiento	1+
			Deterioro	1-
IN	INTENSIDAD	Grado de alteración (mejoramiento o deterioro) del factor como consecuencia de la acción. Puede variar progresivamente desde baja, media, alta, muy alta, hasta alteración total.	Baja	1
			Media	2
			Alta	4
			Muy alta	8
			Total	12
EX	EXTENSIÓN	Porción del área de influencia del proyecto que se prevé podría ser impactada por la acción considerada. Puede inferirse según porcentaje del área de influencia impactada.	Puntual	1
			Parcial	2
			Extenso	4
			Total	8
			Ubicación Crítica	12
MO	MOMENTO	Tiempo de manifestación del impacto. Tiempo que transcurre desde el inicio de la acción y el inicio del impacto que produce. Largo plazo (> 5 años), Medio plazo (1 a 5 años), Inmediato (< 1 año), Momento crítico.	Largo Plazo	1
			Medio Plazo	2
			Inmediato	4
			Momento Crítico	8
PS	PERSISTENCIA	Tiempo que se espera permanezca el impacto desde su aparición. Normalmente se considera fugaz (menos de 1 año), temporal (1 a 3 años), pertinaz (3-10 años) y permanente (más de 10 años).	Fugaz	1
			Temporal o pertinaz	2
			Permanente	4
PR	PERIODICIDAD	Regularidad de la manifestación del impacto. Puede ser irregular (aperiódico, discontinuo), periódico y continuo.	Irregular	1
			Periódico	2
			Continuo	4
RV	REVERSIBILIDAD	Posibilidad de que el factor impactado vuelva a sus condiciones iniciales por medios naturales (resiliencia): Corto plazo (< 1 año), medio plazo (1 a 10 años), irreversible (> 10 años)	Corto plazo	1
			Medio plazo	2
			Irreversible	4
SI	SINERGIA	Reforzamiento o debilitamiento del Impacto como consecuencia de dos o más Acciones sobre un mismo Factor Ambiental. Una Acción = Sin Sinergismo. Algunas = Sinérgico. Todas = Muy Sinérgico.	Sin Sinergismo	1
			Sinérgico	2
			Muy Sinérgico	4
AC	ACUMULACIÓN	Un impacto es acumulativo si la presencia continuada de la acción hace que el impacto crezca con el tiempo.	Simple	1
			Acumulativo	4
CE	CAUSA/EFECTO	Directo si es la acción misma la que origina el impacto. Indirecto si es otro impacto	Indirecto	1
			Directo	4
RC	RECUPERABILIDAD	Posibilidad de que el factor impactado vuelva a sus condiciones iniciales mediante gestión ambiental. Normalmente se define: Inmediato (< 1 año), Medio Plazo (1-5 años), Mitigable (5-10 años), Irrecuperable (>10 años).	Inmediato	1
			Medio Plazo	2
			Mitigable	4
			Irrecuperable	8

NES_i = Index of the Net Environmental State. It is calculated by eqn (6):

$$NES_i = f(\Delta M_i) = f(Mwp_i - Mop_i), \tag{6}$$

where

- (Mwp_i) = Dimensional magnitude in condition with project
- (Mop_i) = Dimensional magnitude in condition without project
- $f(M_i)$ = Transformation function to dimensionless units

2.4 Logical Framework Matrix (LFM)

The Logical Framework Matrix (LFM) is the essence of the SEIA methodology. It allows to calculate in an integral and systemic way the value of the impact on each environmental factor, as well as the impact generated by each action on the environment (Table 3).

The LFM allows to interrelate, in the columns, the significant actions A_j that produce significant impacts, and in the rows, the environmental factors (F_i) susceptible to be impacted by the actions, be parameterized (indicators and their magnitude) condition without project (Mop_i). For each interrelation (Action–Environmental Factor) was determined: the Intrinsic Importance (I_{ij}) of the identified impact, the variation of the magnitude of the factor considered in its condition with project (Mwp_i) (dimensional quantitative assessment), and the value of the environmental impact (V_{ij}), which involves the qualitative and quantitative assessment, but calculated dimensionally with the help of the transformation function $f(M_i)$.

In short, the LFM allows a comprehensive and systemic visualization of the qualitative assessment (intrinsic importance) of each environmental impact generated, the variation of the net magnitude of each environmental factor from the condition without project (op) to the condition with project (wp), the quantitative assessment (dimensionless) of each impact generated, and of course, the total environmental impact of the project or of each alternative considered.

Table 3: Logical Framework Matrix (LFM). *(Source: Author.)*

ENVIRONMENTAL FACTORS	Magnitude in Condition Without Project Mop	P [0-1000]	Condition With Project (wp) PROJECT ACTIONS A_j	Qualitative Assessment ENVIRONMENTAL DETERIORATION AND / OR IMPROVEMENT	Transformation Functions Environmental State ES = f(M)	Quantitative Assessment TOTAL IMPACT VALUE ON EACH FACTOR
F_i	Mop	P_i	I_{ij}	$I_i = \frac{P_i}{1000} \cdot \sum_{j=1}^{j=m} Mwp_{1j}$		$\lvert V_i \rvert = \left[\frac{\lvert I_i \rvert}{\max \lvert I_i \rvert} \cdot (NES_i)^2 \right]^{2/3}$
			Mwp_{ij}	$Mwp_i = \sum_{i=1}^{i=m} Mwp_{ij}$	$NES_i = f(Mwp_i - Mop_i)$	
			$\lvert V_{ij} \rvert = \left[\frac{\lvert I_{ij} \rvert}{\max \lvert I_{ij} \rvert} \cdot (NES_{ij})^2 \right]^{2/3}$			
Qualitative Assessment AGGRESSIVENESS AND / OR GOODNESS OF EACH ACTION			$I_{Aj} = \sum_{i=1}^{i=n} P_i . I_{ij}$			
Quantitative Assessment ENVIRONMENTAL IMPACT FOR EACH ACTION AND TOTAL			$EI_i = \sum_{i=1}^{i=n} P_i . V_{ij}$			$TEI_k = \sum_{i=1}^{i=n} P_i . V_i$

3 RESULTS AND DISCUSSION

3.1 SEIA methodology applied to projects

The SEIA methodology applied to projects is constituted in an Environmental Impact Assessment (EIA) process, oriented to define the corresponding Environmental Management Program (EMP), which identifies, mitigates and/or eliminates the environmental impacts generated by the project under study. Fig. 2 schematizes the process diagram that involves the development of the SEIA methodology.

3.2 SEIA methodology applied to Policies, Plans and Programs

The SEIA methodology applied to Policies, Plans and Programs configures the so-called "Strategic Environmental Assessment – SEA" [5], which aims to incorporate environmental and sustainable development criteria into sectoral and or territorial strategic decisions, as a basic input for decision-making, and for the formulation of Strategic Environmental Programs [6]. Fig. 3 schematizes the process diagram that involves the development of the SEIA methodology.

3.3 Environmental licensing under the SEIA methodology

The SEIA methodology will be closely linked to the environmental licensing process advanced by the environmental authority [7], as shown in Fig. 4.

4 SOME EXPERIENCES OF APPLICATION OF THE SEIA METHODOLOGY

4.1 Environmental evaluation of hydro-sedimentation management alternatives in the Canal del Dique, Colombia

Objective: Identify, assess and analyze, in accordance with the requirements of the Ministry of the Environment, the environmental impacts derived from the different

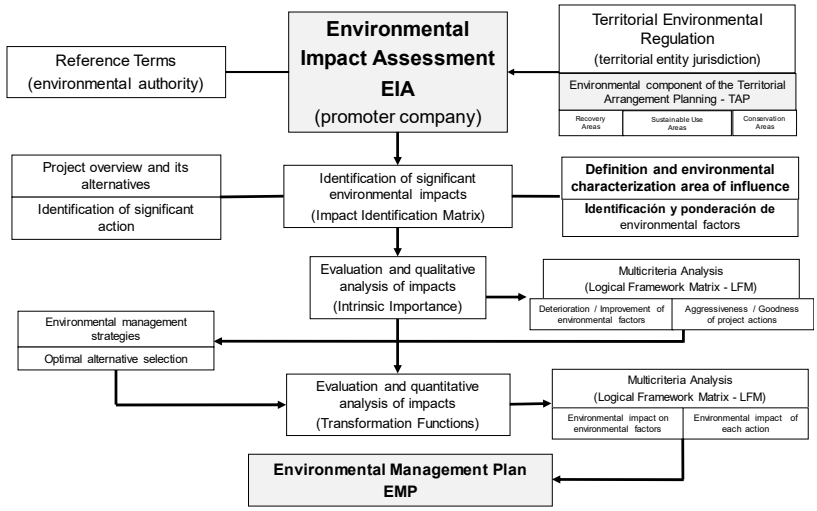

Figure 2: Diagram processes of SEIA methodology applied to projects. *(Source: Author.)*

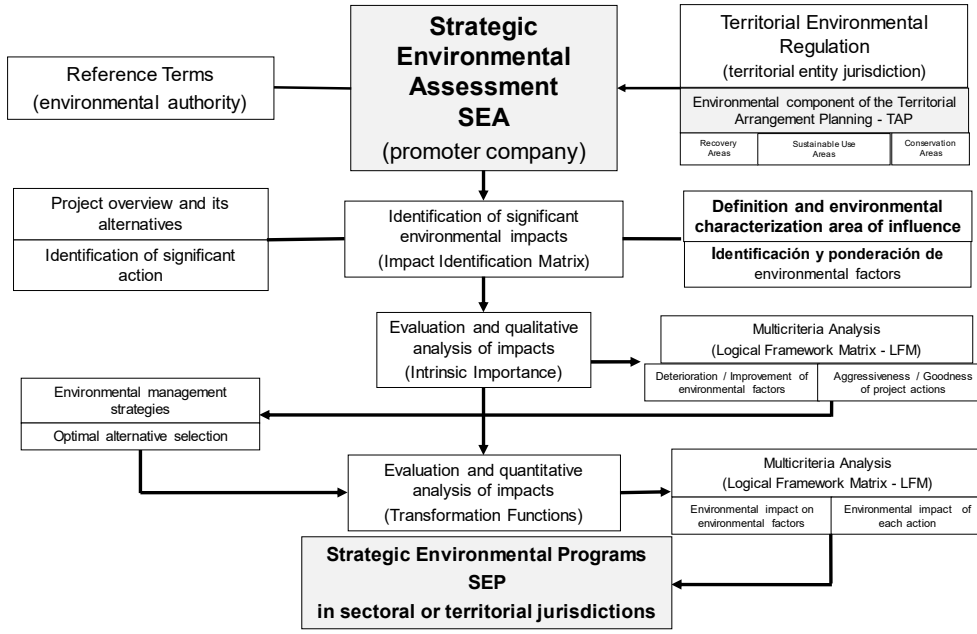

Figure 3: Diagram processes of SEIA methodology applied to Policies, Plans, Programs. *(Source: Author.)*

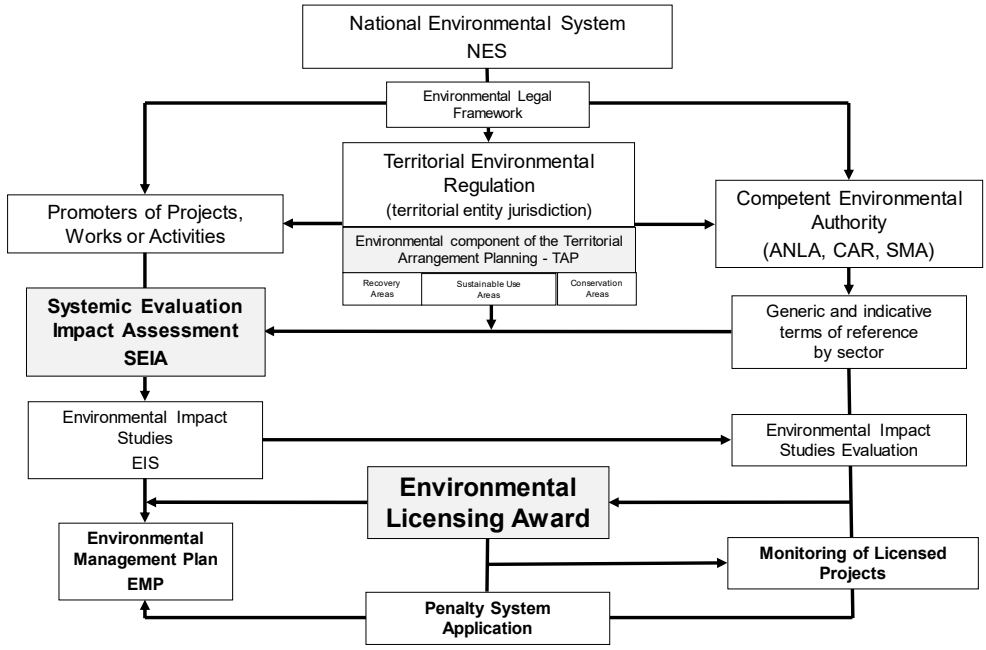

Figure 4: Environmental licensing under the SEIA methodology. *(Source: Author.)*

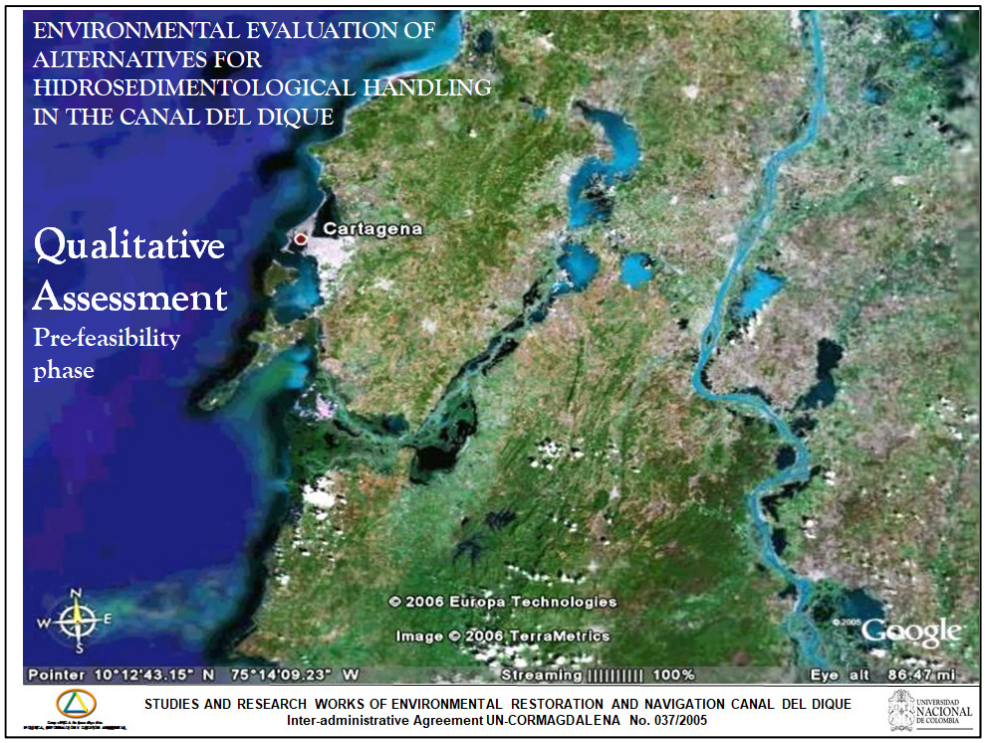

Figure 5: Environmental evaluation of hydro-sedimentation management alternatives in the Canal del Dique, Colombia. *(Source: [8].)*

hydrosedimentological management alternatives considered in the studies and investigations of the environmental restoration and navigation works of the Canal del Dique, as a fundamental input for decision making.

Methodology: Based on the physical and mathematical modeling of the hydrological, hydraulic, ecosystemic, social and economic conditions of the Canal del Dique region, and in the light of the methodology of "Systemic Environmental Impact Assessment (SEIA)", they identify and value qualitative level, the environmental impacts generated for each considered hydro-sedimentological alternative.

Results: As a fundamental input for decision making, the qualitative assessment of the environmental impacts generated on each of the environmental factors considered was obtained, as well as the qualitative assessment of the environmental impacts generated by each action, for each of the Hydrosedimentological management alternatives considered.

4.2 Comprehensive evaluation of volcanic risk: Cerro Machín volcano, Colombia

Objective: To investigate and determine the threats, vulnerabilities and risks faced by the population, the constructed elements and the ecosystems located in a sector of the area of influence of the Machín volcano, specifically in the corresponding sector of the Department of Tolima.

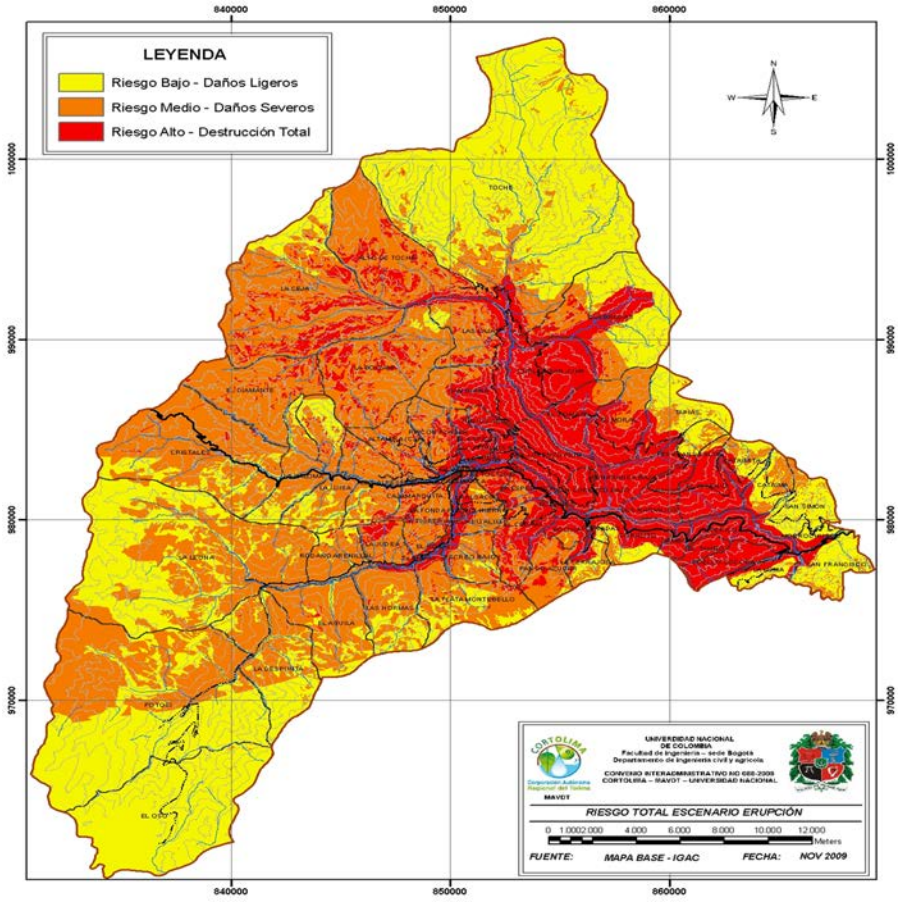

Figure 6: Comprehensive evaluation of volcanic risk. Cerro Machín volcano, Colombia. *(Source: [9], [10].)*

Methodology: Based on the volcanic hazard studies previously conducted by the Colombian Geological Service (CGS), and in light of the methodology of "Systemic Environmental Impact Assessment (SEIA)", new equations are generated and applied to calculate the threats, vulnerabilities and risks, making use of information processing and analysis techniques and tools of Geographic Information Systems (GIS).

Results: Risk maps for the crisis and eruption start scenarios, as well as maps of escape routes and relocation for the same scenarios.

4.3 Hydro-sedimentological and environmental assessment in the La Mojana region, Colombia

Objective: Identify, evaluate and propose the general guidelines aimed at foreseeing, mitigating, eliminating and/or controlling the environmental impacts derived from the different necessary and priority infrastructure works for the Environmental Regulation and Territorial Development of the Mojana Region.

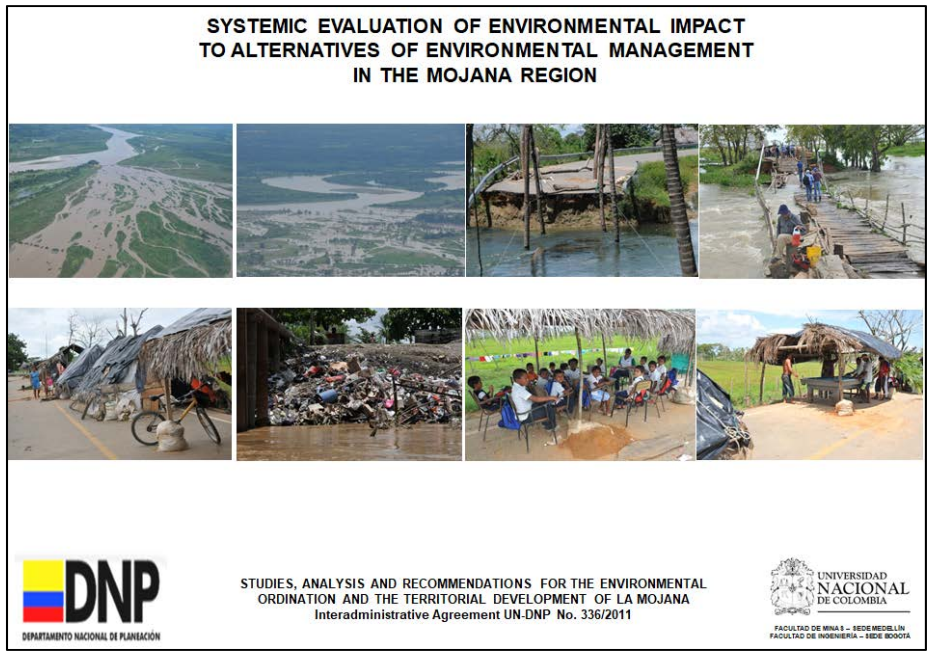

Figure 7: Hydro-sedimentological and environmental assessment in the La Mojana region, Colombia. *(Source: [11].)*

Methodology: Based on the mathematical modeling of the hydrological, hydraulic, ecosystemic, social and economic conditions of the Canal del Dique region, and in the light of the methodology of "Systemic Environmental Impact Assessment (SEIA)", they identify and value qualitative level, the environmental impacts generated for each of the regional development scenarios considered.

Results: As a fundamental input for decision making, the qualitative assessment of the environmental impacts generated on each of the environmental factors considered was obtained, as well as the qualitative assessment of the environmental impacts generated by each action, for each of the regional development scenarios considered.

5 CONCLUSIONS AND RECOMMENDATIONS

- The SEIA methodology constitutes a valid option for the evaluation of environmental impact.
- Despite being a very demanding methodology in terms of quantity, quality and availability of information, once it is collected, aggregated and ordered by the EPG Matrix, the processes of identification and assessment (qualitative and quantitative) of impacts through the multicriteria analysis, as well as the indicative systematization of results, greatly facilitate analysis, decision making and, in short, the entire environmental impact assessment process.
- In application of the principles of precaution, gradualism, economy and continuous improvement, the development and implementation of the SEIA methodology requires thinking about large and important changes in environmental management, as a step prior to decision making and the development of the Environmental Licensing process.

- In the short and medium term, progress must be made in the formulation of a national environmental policy of a state nature, which guides, dynamizes and adequately articulates environmental management towards:
  - the environmental order of the territory;
  - strengthening the role of environmental authority;
  - the real participation of civil society and of course;
  - the systemic evaluation of the environmental impact.
- In the long term, a corporate environmental culture is glimpsed that has internalized the SEIA to the point that the process of environmental licensing in prototypical projects by the environmental authority could be reduced to a simple control for the assurance of the environmental management plan.

REFERENCES

[1] Colombia, Ley 99/93, Por la cual se crea el Ministerio del Medio Ambiente (MMA) y se organiza el Sistema Nacional Ambiental (SINA), Bogotá, 1993.
[2] UN-PIGA, Lineamientos y recomendaciones generales para el mejoramiento de la evaluación de impacto ambiental en Colombia. Convenio Interadministrativo UN-MADS No. 033/2013, Universidad Nacional de Colombia, Grupo PIGA de Investigación en Política, Información y Gestión Ambiental: Bogotá, 2013.
[3] Vega, L., Toward the systemic parameterization of the environmental dimension. *Revista Ingeniería e Investigación*, **31**(1), pp. 242–253, 2011.
[4] Conesa, V., *Guía metodológica para la evaluación del impacto ambiental*, 4th ed., Mundi Prensa: Madrid, 2010.
[5] MAVDT, Guía práctica para formular evaluaciones ambientales estratégicas en Colombia. Equipo redacción Guía de EAE. Ministerio del Ambiente, Vivienda y Desarrollo Territorial: Bogotá, 2008.
[6] UN-PIGA, Marco conceptual y metodológico para la construcción conjunta de Planes Integrales de Gestión Ambiental Sectorial – PGAS. Convenio Interadministrativo UN-MADS No. 338/2015, Universidad Nacional de Colombia. Grupo PIGA de Investigación en Política, Información y Gestión Ambiental: Bogotá, 2015.
[7] Vega, L., La Dimensión Ambiental del Desarrollo. ECOE Ediciones. Colección Ciencias Naturales, Área Ecología y Medio Ambiente: Bogotá, 2017.
[8] UN-LEH, Estudios e investigaciones de las obras de restauración ambiental y de navegación del Canal del Dique. Informe Principal. Cormagdalena – Universidad Nacional de Colombia, Laboratorio de Ensayos Hidráulicos: Bogotá, 2008.
[9] UN-PIGA, Estudios y análisis de vulnerabilidad y riesgo en un sector del área de influencia del Volcán Machín. Convenio Interadministrativo UN-CORTOLIMA-MAVDT No. 088 de 2008, Universidad Nacional de Colombia. Grupo PIGA de Investigación en Política, Información y Gestión Ambiental: Bogotá, 2009.
[10] Vega, L., Evaluación integral del riesgo volcánico. El caso del Volcán Machín, Editorial Universidad Nacional de Colombia: Bogotá, 2013.
[11] UN-PIGA, Estudios, análisis y recomendaciones para el ordenamiento ambiental y el desarrollo territorial de la Mojana. Convenio Interadministrativo UN-DNP No. 336/2011, Universidad Nacional de Colombia, Grupo PIGA de Investigación en Política, Información y Gestión Ambiental: Bogotá, 2012.