University of Social Sciences in Łódź

Rosa Elia Martínez Torres

Sustainable Management Model applied to the Metallic Mining Industry in Mexico: Case Study in San Luis Potosi

Doctoral dissertation written under the supervision of
dr hab.inż. Mariusz Bednarek prof. WSB Warszawa

Łódź, 2021.

Environmental Management, Sustainable Development, Mexican Mining legislation, Metallic Mining Industry, Environmental Impact Manifest

INDEX

INDEX OF TABLES

INDEX OF FIGURES

CHAPTER I. RESEARCH APPROACH

CHAPTER II. THEORETICAL BASES

CHAPTER III. ORIGINALITY RESEARCH: SAN LUIS POTOSI´S MINING INDUSTRY ANNOTATIONS

CHAPTER IV. SUSTAINABLE MANAGEMENT MODEL FOR MINING METALLIC INDUSTRY OF MEXICO: METHODOLOGICAL DEVELOPMENT

CHAPTER V. CASE STUDY IN UNDERGROUND METALLIC MINE: DESCRIPTION OF RESULTS

MAIN ABBREVIATIONS

SDGs	Sustainable Development Goals
EIM	Environmental Impact Manifest
MSJ	Unit of analysis[1]
ASI	Corporative of the unit of analysis
NOM	Norma Oficial Mexicana [Official Mexican Standard]

NOTE TO READER

This research work presents a rigor based on the Scientific Method, with a qualitative approach and method of descriptive-interpretative analysis, which through methodological development through a Simple Holist Case Study, contributed to solve research questions, hypotheses and development of objectives. It presents as a result a Sustainable Management Model designed with literary foundation and international and national considerations that adhere to the culture of the mexicans labors. The analysis unit belongs to a mining unit in the metal sector: silver, located in the state of San Luis Potosi, Mexico.

The wording of this document is aligned by the APA writing style, which emphasizes the citation in text to accredit the original author from whom the idea originates, as well as the year in which his contribution is disseminated.

[1] For confidentiality at the request of the subject under study, the name of the analysis unit will be ignored in the entire research work.

CHAPTER I. APPROACH TO RESEARCH

PRESENTATION

This chapter shows, in a general way, the approach to the research in the setting of the Environmental Management from the point of view of Sustainability, reviewing the meanings that promote the relationship between them; in addition to this it is described from the point of view of the objectives of Sustainable Develpment. From the Sustainable Development Goals (SDGs), an overview of the action scene for actions on a worldwide level, and, on the basis of their purpose for the environment, four of them are reconsidered within this investigation to perform field work.

The objective of this research is to propose a Model of Sustainable Management that will allow the firms of Mexico's Mining Industry, from their Operative Running, to perform environmental practices that are in line with universal principles of: *Industry, Innovation and Infrastructure, Responsible Production and Consumption, Sustainable Cities and Communities* and*, Life of Terrestrial Ecosystems,* in addition to compliance with the regulations prescribed by the country for the benefit of the environment in order to eliminate or minimise impacts or risks to the milieu. In addition to this the purpose is established to gain knowledge of the actual Envirnment Management of a mining-metallurgical sector, trying to collect information along two main axes: (1) international guide for the care of the environment: Agenda 2030 of Sustainable Development, and, (2) official document for evaluation of the Legislative compliance of environment practices in Mexico: Environmental Impact Manifest (EIM).

This chapter presents the methodological vision that conforms to the Scientific Method, describing about the research objectives, the delimitation of the study, the hypotheses, the investigative questions and, the scope; the expected practical results of this research are also described.

An introduction to the originality of the study and justification as relevant research work is presented, which is expressed on the basis of Chapter III.

1. Introduction

1.1 Importance of the mining-metallurgical sector for Mexico.

The Mining-metallurgical Industry is a strong economical contributor in Mexico, and, geologically its geography stands out because of its mineral wealth. Worldwide, Mexico is within the 12 principal producers of 20 minerals (SGM, 2017).

A mineral deposit is defined as an infrequent combination of processes related with the origin and transformation of the various rock groups constituting the Earth's crust. The conditions for their economical accumulation frequently depend on the structural characteristics of the area where the deposit is located; it is the result of a natural geological process which is described according to its geoeconomical potential in a metalogenic[2] map, which itself requires the analysis and classification of the known mineral deposits in relation to their geological surroundings (SGM, 2017).

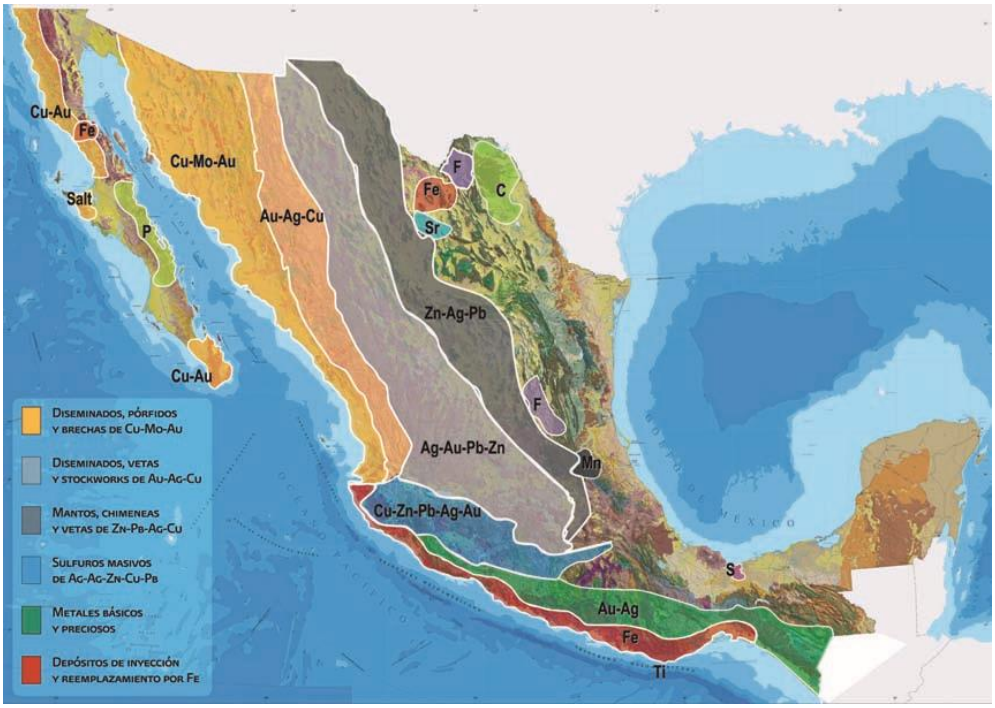
The Geological Map has the purpose of evaluating, with added precision, the general potential of the specific products of the metalogenic processes, as it provides the limits of zones which are favourable for exploration by providing coincidence at a certain time point of the parameters that have interacted to procuce a mineralized area (SGM, 2017).

Each region (province) was selected on the basis of its own and integral geological characteristics, which exclude one or a handful of geological mineralisations, in order to rationalise the general policies of evaluation and exploration of the potential geoeconomy of Mexico (SGM, 2017).

The following figure (1) shows, classified, the wealth of the Mexican subsoil:

[2] ***Metalogenics***. Term used by French and British geologists (economical geology) to designate the set of subjects that study mineral deposits.

Figure 1. Metalogenic Provinces of the Republic of Mexico.



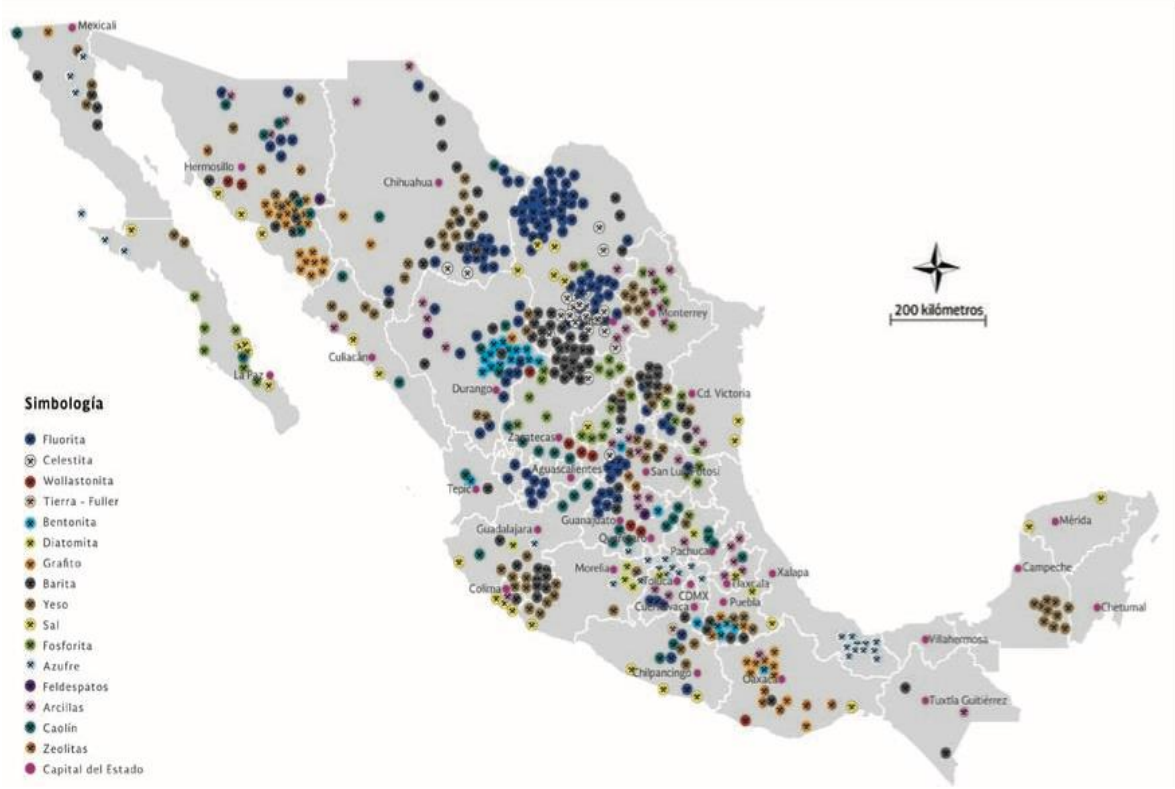
Legends - inset:
* * * * * * *
* Scattered, Porphyry & Breccias of Cu-Mo-Au
* Disseminated, Veins, Stockworks.of Au-Ag-Cu
* Strata, Chimneys, Veins of Zn-Pa-Ag-Cu
* Massive Sulphurs, Ag-Zn-Cu-Pa
* Basic and precious metals
* Injection and Replacement Deposits of Fe
* * * * * * * *

Source: Servicio Geológico Mexicano [Mexican Geological Service] (SGM, 2017).

The existence of deposits of great quality favours investment in projects because they produce good income. Of Mexico's territory of 1,964,375 km², 70% (1,375,060 km²) have a geological evolution favourable to the development of Mining Projects, which promote the country as one of the most important worldwide for these projects, because of the quantity and quality of mineral deposits throughout its territory (SE, 2017).

Mexican mining industry produces 53 minerals, of which 11 are metallic and 42 non-metallic, and additionally includes in its geological wealth a quantity of substances that can be exploited; figure 2 shows the non-metallic deposits of the national territory (SE, 2017):

Figure 2. Non-metallic deposits in the Republic of Mexico.



Symbols (same order as above)
* Fluorite
* Celestite
* Wollastonite
* Fuller earth
* Bentonite
* Diatomite
* Grafite
* Barium Oxide
* Gypsum
* Salt
* Phosphorite
* Clays
* Kaolinite
* Zeolites
* State Capitals

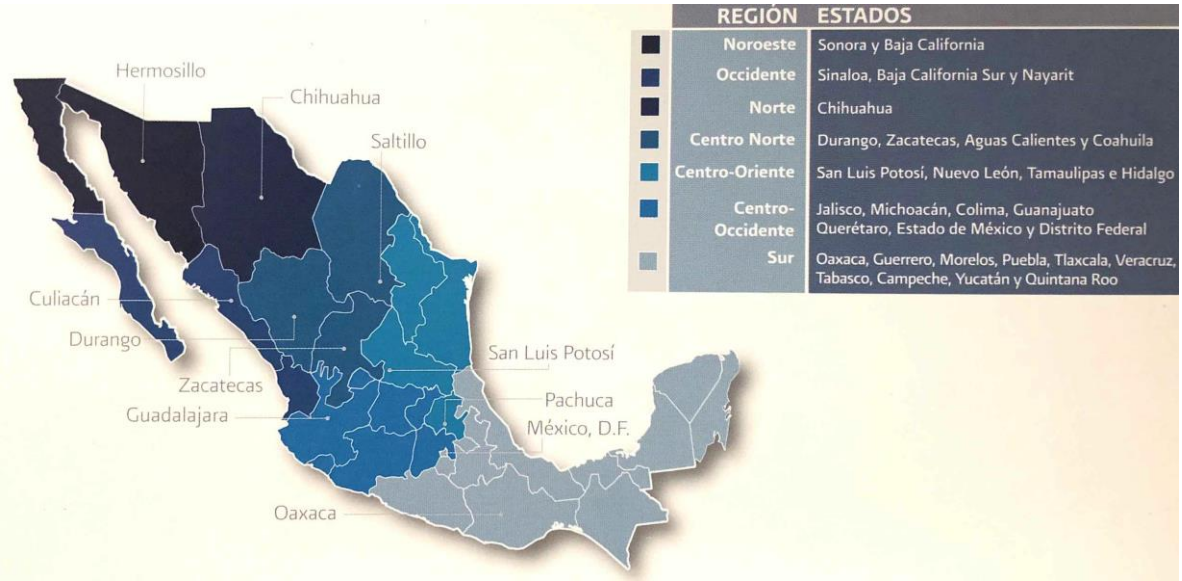
Source: Servicio Geológico Mexicano [Mexican Geological Service] (SGM, 2017).

The distribution of the mineral deposits as well as of the non-mineral ones in the national territory is very extense and vast as the last figures show. The Direction of Documents and strategic pointers of the country register the participation of Mexico in the world mine production at the end of 2016, taken from the information of the Mineral Commodity Summaries (2017):

First place in the production of Silver, participating with 25% of the world's output; second place in Fluorite, reaching 11%; third place in Bismuth, Celestite and Wollastonite with a participation of 5%, 11% and 9% respectively; fifth place in world production of Molibdene with 5%, as well as 5% of Lead and 6% of Zinc. Cadmium production achieves sixth world output with 6%; Diatomite with 4% and Copper with 5% reach seventh place, whereas Gold with 6% and Salt with 4% reach the eighth position. Ninth is gotten by Manganese with 1% and Gypsum with 2%, and, Barite occupies the tenth position with 2% of the world's output.

In this industrial sector, metallic minerals are usually located in strips, which are known as "*Mineralization Trends*", having, as was illustrated in Figure 1 extension the length of the country, and, for identification the adjective representing the most abundant metal of the trend. On the other hand, the non-metallic minerals (figure 2), have a non-classifiable presence along the Mexican territory, so the classification results complex, the location being made for practical purposes and for project identification (mines) through zones (figure 3):

Figure 3. Representative Geographic mining regions of the Mexican Republic.



Source: Servicio Geológico Mexicano [Mexican Geological Service] (SGM, 2017).

2. Justification

2.1 Importance

The importance of undertaking an investigation of the Mining Industry in Mexico is due to the fact that it constitutes a sizable economic factor in the country. According to data of INEGI (2017 and 2018) this sector capitalised 9% in the country and 8.3% of the industrial GDP, 2.9% and 2.5% of the national GDP respectively.

In 2016, despite negative indicators (imposition of new levies, impossibility of deducting the 100% of pre-operative exploration expenses on the same year they are expended, drop in the demand of metals and economical deceleration of the country), production in this sector manages to reach 19.6% more than in 2015, getting to 7 thousand and 728 million dollars; mineral exports achieve 24 million 375 thousand and 905 metric tons, which represent a reduction of 11.7%, whereas imports increase 18.1%, so the load change to the mining industry diminishes 5.4% in 2016, registering a figure of 69 million 654 thousand and 974 tons (23.4% of the national total).

In 2017 minerals shifted abroad record a decrease to 23 million 40 thousand and 781 tons (6.8% less than the previous year), imports on the contrary increasing 2.2% registering for the sector 71 million 491 thousand 612 metric tons, which correspond to 40% of the national total. The value of the mining-metallurgical production increases 1.8% to the quantity of 12 thousand 772 million dollars, explained by the increased value of some metals.

In 2017 the generation of foreign currency also increases, reaching 17 thousand 489 million dollars, placing mining under the automotive, electronic, remittances, crude oil, tourism sectors and only above the agro-industrial one. According to information from the “Instituto Mexicano del Seguro Social” (Social Security Institute), at the close of 2017 a growth of 4.8% was accounted for, equivalent to 16 thousand 854 new jobs (almost twice the jobs generated in 2016) to reach the total of 371 thousand 556 direct jobs; the salary income of workers in the mining-metallurgical industry is 32% greater than the national average.

2.2 Relevance

The relevance of performing a research on the Mexican Metallic Mining Industry, involves the present international proceedings on environmental topics. This study focuses on Sustainability Principles in order to concentrate on management practices that in this sense are practiced by units of the sector, and that historically have been involved in ecological and social problems as a result of the agressiveness of its processes, due to the fact that the natural non-renewable resource is extracted directly from nature, and on the other hand the mineral is separated from the inert material through processes that involve contamination of the air, the soil and the water upon transferring waste particles into the environment

Mexico is the first destination of mining exploration investment in Latin America and the 4th in the world (SNL Metals & Mining, 2019) achievements accounted for due to its position within the six main strategic sectors of the country: it stands in the 5th place as it capitalises 4% of the national GDP; 34.89% of the economically active population belongs, directly or indirectly to this industry, and the salaries of workers are 32.% higher than the national average (INEGI, 2018).

In addition to the above, the Metallic Mining Industry accounts for 50.38% of the total mining production of the country, of which the production of silver, which contributing with 10.25% (SGM, 2019) constitutes the first place in the world. The state of San Luis Potosí supplies 3.3% of this total per year (SE 2019).

2.3 Pertinence – Environmental impact

Countries, companies, organizations and society, have created awareness in recent years about the damage caused by the intervention of man, in the environment, trying to justify this fact in development and progress. Faced with the possibility of reversing this environmental impact, global efforts have been made to promote strategies, programs and plans that serve as a guide for organizations in their different possibilities and scopes, to collaborate and actively participate in the recovery, eradication, minimization and promotion of new public policies that regulate the daily action of activities, operations, processes (UN, 2016).

This doctoral project adheres to the effort made by countries organized by the United Nations, in its version of Sustainability, which disseminates to all members, a guide presented under schemes of objectives and goals to be achieved in the coming years to meet current and future needs, promoting above all, the equitable use of natural resources based on the development of the communities of the countries. This effort is presented in descriptive format under the Sustainable Development Goals (SDGs), called the Agenda 2030.

Based on a methodology that raises a study on the approach of mining units in Mexico to the international proposal Agenda 2030, this project is considered pertinence once it seeks to promote through the Management of this industrial sector, miminize the environmental impact caused by the nature of the operation.

3. Problem Statement

3.1 Delimitation

Taking into consideration the metalogenic provinces of the country as well as the diversity of minerals, both metallic and non-metallic, together with the type of operations for their extraction, after a field visit of the units for selection of those to be included in a doctoral thesis work in the area of Environmental Management, in a first exercise of delimitation four units of the mining-metalurgic sector were selected by their nature and availability for field work, classified as underground mine, open cut mine and refining plant, in addition to chosing a unit that has finalised its operations.

The metallic mines belong to the *Ag-Au-Pb-Zn trend*, the non-metallic one and the refinery belong to the Centro Norte and Centro Sur Regions.

The unit for analysis is extracted after a selection that implies rapprochement through visits and interviews with the administrators of four mining units shown in Table 1; it was planned additionally to include mining units of groups of different corporations, as well as information on the principal and secondary minerals when these are profitable for the units, and geographic location.

Table 1. Mining-metallurgical units pre-selected as available for participation

CLASSIFICA-TION	NAME OF THE UNIT	CORPORATIVE GROUP	EXTRACTED / PROCESSED	TREND / REGION LOCATION
Underground Mine	MSJ	ASI	Silver, Lead concentrate	Ag-Au-Pb-Zn Trend
Open pit Mine	MLL	EMM	Feldespar concentrate	Centre South Region
Refinery	REZ	GIMM	Zinc, Sulphuric Acid	Centre North Region
Operations closure	MSX	NGI	Gold, Silver	Ag-Au-Pb-Zn Trend

Source: Own preparation.

This first analysis for selecting the mining unit was made on the basis of convenience, according to Hernández (2018). In the same manner, for convenience, the **MSJ MINING UNIT** is selected, which is a mine of **underground exploitation**, which supplies **metallic mineral** relevant to the country: Silver, which is located in the State of San Luis Potosí, bordering with the State of Zacatecas. This selection is based additionally on importance and originality of objectives as well as scope of the investigation.

3.2 Approach to the problem

As in all complex systems, the Metallic Mining Industry has chiaroscuros that are not easy to discern. When one expands in how the industry has developed technology wise, the question arises as to the impact of this progress on the environment. The negative effects of the development of the mining industry can be observed in the ecology and in the societies that this impact affects (Martínez and Bednarek, 2018).

The damage to the environment that the industry can cause, is reflected in the pollution of water, soil, air, degradation of resources, ecosistems, etc. considering that volumes of untreated residual solids, liquids and gases are liberated onto the environment, which additionally do not enter into the accounting of production costs. These negative effects vary with the type of mineral and mine, which by their nature imply the exploitation of a non-renewable resource through processes like crushing,

grinding, washing, lixiviation and mineral classification, refining and melting (IIED/WBCSD, 2002).

The problems of the environmental type arising from the bad practices in the mining sector are a consequence of the inexistence or lack of adherence to the prescriptions of regulations and legislation along time; indeed, sites contaminated with organic and inorganic substances derived from mineral exploitation, extraction and benefit processes have been identified (Volke and Velasco, 2002). It is about rural, urban and semi-urban spaces being affected, in soil, air and/or water, producing the gradual deterioration of the ecosystem, as a consequence of practices whose absent management systems for regulation of the impact caused by their mining industrial processes generate.

In order to get information on how the companies of the metal mining industrial sector comply in their operations to policies on the preservation of their environment, it will be necessary to analise, design and apply a research study on the practices of Environment Management that are concerned with the daily Environs Sustainability lived within the units that have been historically on the receiver end of critics, social problems and radical politicians.

3.3 General and Specific Objectives

3.3.1 General Objective.

To propose a Sustainable Management Model tha will enable Mexico's Metallic Mining Industry, from its management action, to perform environmental practices that aling to universal principles of Sustainability (PNUMA, 2010) in addition to the compliance with the Legislation (SEMARNAT, 2002) to erradicate or minimise impacts or environmental impact risks.

3.3.2 Specific Objectives.

1. Perform literary analyses with the purpose of relating the foundations of Sustainability and the bases for the Legislation of the Mexican Mining Industry.

2. Analyse the environmental practices that are current in the Metallic Mining

Industry of Mexico on the basis of an underground mine that contributes to the production of Silver.

3. Develop a Model tha enables the evaluation of the environmental practices of the Mexican Metallic Mining Industry, with reference to the compliance of the Principles of Sustainability.

4. Propose the best practices that will guarantee the Metallic Mining Resource (Silver) in San Luis Potosí and define reccomendations for the Industry of the Metallic Mining of Mexico.

3.4 Research Environment

An investigation is made into the mining-metallic sector, which in itself is a part of a productive activity which is conclusive in the world history of humanity. Its importance is asserted in the same manner as the telecommunication industry, transportation and manufacturing as for generations it has represented transcendental social and economical transformations (Góngora, 2013).

Mining Indystry It is actually an integrated activity, considering that the extracted mineral resources require an industrial transformation to enable them to be used, getting to be known as Mining-metalurgical Industry (Saavedra and Sánchez, 2007) that focus itself in the search of the satisfaction of daily needs that are on the rise in the world.

The Mining Industry constitutes an important economical stronghold for some countries. In 2017 it achieves that 120 economies register increases in the investment of foreign capital, productivity, exports and employment; all these matters constituting essential factors for the continuous financial movement to countries involved in the mining sector (CAMIMEX, 2018)

The confines of the investigation imply the analysis of a unit of the Metallic Mining Industry, that as such should present procedures of Environmental Management that translate into Sustainability, which it is claimed to prove through universal principles belonging within the Sustainable Development Goals described in the *Agenda 2030*.

3.5 Research Questions.

Does a relation exist on the basis of the Sustainability and the Legislation in mining matters to establish the correct literary application, through a practical model for its follow up in units of the sector in Mexico?

Is it possible to learn, by means of one unit, representative of the mining sector, the environmental practices practiced? Are such practices guided by the Legislation that evaluates them?

What type of information is generated through the implementation of a Management Model based in theory on Sustainability?

Is it possible to make the implementation of a Model of Sustainable Management extensive to a complete industrial sector?

3.6 Formulated Hypotheses - Assumptions

On the basis of the present economical context, it is noticed how present governments strive for the national and international policies to have more influence among them; on the other hand, the companies dispute global markets between them and the information on public policies and over the internal organisational behaviour grows in importance. Facing this, public perception begins to recognise thet the dominant economical and social developments imply a growing environmental deterioration.

- Research studies related with the environmental mining practices have focused mainly on the ecological damage, therefore their results are not aligned with the Sustainability Principles in the Metallic Mining Industry of Mexico.

- The determination of the environmental procedures aligned with the Sustainability Principles in Mexico shall be made possible through an investigation of the Metallic Mining Industry.

- Definition of the best environmental practices entails the implementation of a Model of Sustainable Management and its field validation in the Metallic Mining Industry, particularly the metallic mineral resource in San Luis Potosí (Silver). It is

allow to extend a set of recomendation for mexican Metallic Mining Industry.

3.7 Expected Results.

1. Ananysis, interpretation and description of the Sustainable Principles: *Industry, Innovation and Infrastructure, Sustainable Communities and Cities, Responsible Production and Consumption, and, Lifespan of Land Ecosystems,* relative to the metallic mining sector.

2. Construction, presentation and validation of a Model of Sustainable Management for the Mining and Metallic Industry of Mexico, with a sustainable foundation and national Legislative compliance.

3. Analysis, interpretation and description of the observations made upon the implanting of the Model of Sustainable Management for the Metallic Mining Industry, as the core of the field work in the mining unit located in the Au-Ag-Pb-Zn metallic Trend.

4. Description of best practices observed in the mining unit located in the Au-Ag-Pb-Zn metallic Trend through the implementation of the Model of Sustainable Management for the Metallic Mining Industry.

5. General Reccomendations based on the set of interpretations made through the implementation of the Model of Sustainable Management in the mining unit located in the metallic Trend Au-Ag-Pb-Zn, that at the same time promote the possibility of implementing the Model in Mexico's metallic mining sector.

Reflection

Many countries do not strictly comply with the regulations in relation to impacts on the environment, and they consequently degrade the quality of water, air, biotic and abiotic life; additionally, for various reasons, among them the termination of extraction due to an exhausted mineral resource, the mining unit closes and the valuable equipment is removed, even taken out of the country (Morán, 2013).

Among other things, these occurrences mean, for the enterprises of the mining sector, economic costs that aren't recognised and/or legal consequences, as well as the probability of their being visible inconveniences for the environment, a few years later. Morán (2013) also states that regulations for the Mining Industry are not equal for developed countries as for developing ones, suggesting weakness in the regulating institutions in underdeveloped countries.

Consideration, of the useful life of units, due to exploitation of mineral deposits, innovating processes for the mitigation of negative impacts, planned closures to perform remedial actions in the short, medium or long range, that involve costly studies and technical evaluations, collaborations of deep researches, and, above all integral financial plans, that ought to contemplate remediation as permanent back payment to society and the environment (Morán, 2013).

CHAPTER II. THEORETICAL BASES

PRESENTATION

The theoretical bases of this research focus on two main areas for study through the literature review. Based on the trend of conducting research in the mining industrial sector, searches are carried out to delimit topics that provide formal knowledge and format viability, this activity begins simultaneously with the exploration of information from the topic axis of the research: Management. This trend leads the delimitation made after an important compilation, towards Environmental Management within the mining sector in Mexico. Once there is a proposal, the second literary phase begins, the contribution of knowledge through the exploration of global and national topics of environmental care by the industrial sectors.

To start this theoretical section, a conceptual delimitation to be able to provide the required research foundation. Terms such as: Management, Sustainability and Sustainable Development, are the initiators of this literary search, since today they are universal indicators of compliance of the nations committed to the agencies that execute the action guideline, such as the United Nations Organization that, Through their programs, they manage to unite policies and strategies. From these other concepts emerge that were assisting and forming the driving force behind the investigation.

As a second point, a description of the mining-metallurgical industrial sector is made, emphasizing particular issues necessary for the complexity of the investigation. This format allows the reader to deepen their understanding of the industrial sector and its importance, both economically and socially for Mexico and how there are also issues that place it within the group of companies that impact the environment in an aggressive way.

The third point described is the legislation that governs Mexico in reference to the mining sector, concentrating organizations and clauses. This section provides parameters that the sector is obliged to comply with and how regulations analyze through official formats, to allow, evaluate, prohibit, demand and/or provide comprehensive monitoring for the exploitation of the natural resource.

1 Conceptual framework: Environmental Management

1.1 Management

Through the years, Management as a concept has evolved in cultural and organizational frameworks; This evolution is due to dynamic processes of change and growth of administrative thinking. It is not considered a closed activity, since organizations are run and there are decisions within contexts of values and culture, so it is considered an open system with its own characteristics in which members affect their environment and are affected by it. Starting from cultural characteristics, human behavior and the discipline of Management is also the product of economic, social, political and technological forces (Bedeian, 1983).

This cultural context establishes the preconditions for industrializing, formalizing and systematizing knowledge on how to manage. The economics of the market demanded creativity from managers in the face of a competitive and changing environment, and managers had to develop a body of knowledge on how to use resources. It can be said that the beginning was individual thinking and at some point it is situated as generational management. Modern management had to be based on rational forms within decision making. All of these changes have coalesced and evolved over a long period of time as culture changes (Wren and Bedeian, 2009).

Management comprises different elements, measures, strategies and skills, which can be carried out, aiming at making an economic or business activity feasible; for this purpose, four fundamental aspects are related: planning, organization, communication and management control (Guzmán, 2017).

Pérez-Carballo (2013), on the other hand, describes management as a process that is built in parts: planning, organization, execution and control, in order to know and manage it more easily; management control is the function by which the management ensures that resources are obtained and used effectively to achieve the objectives of the organization. This process based on decision making is called: Management Dynamics.

Herrera (2018), integrates the concept of management with reference to innovation, where dynamism starts in the area of human resources and training, favoring the elements: co-create, learn, implement, focus strategies and monitor.

Management, comes from the dynamism that has been generated through its implementation as an activity that basically develops the managers, who are responsible for achieving levels of efficiency and productivity, performing functions of planning, organization, staffing, management and control; to achieve this, personify three managerial roles: interpersonal, information and decision making, involving for this, intellectual skills, human relations and techniques (Bitel and Niewstrom, 1992).

The diversification of Management originates from the dynamism exemplified by various authors in the partition that the functions, activities or phases involved have, according to the purpose of the company or organization in question and, this according to its magnitude, influence and importance complements flexible concepts: business management, labor management, resource management, judicial management, environmental management, the latter being the one where the study that houses this research will be concentrated.

1.2 Environmental management

As part of the evolution towards the concept of modern management, man's relationship with the environment to satisfy his needs is linked to social and economic aspects, considering to a large extent, physical productions on natural bases (Hernández, 2019). Two phases are indicated that refer to environmental management in the evolution of the concept, the first characterized by theories of track adjustments, originated from observations based on the environment; the second, which reaches current stages and focuses on the emergency that exists in this regard, and is classified as reciprocal adjustment theories; both explain social factors and how they relate to the environment to describe theories of environmental law (Bonnicksen and Lee, 1982).

Colby (1991), describes through paradigms the relationship of the human being with nature, presenting at the same time, visions of the interactions as evidence of the functioning of management strategies and problem solving. These paradigms are: (1) frontier economy, (2) deep ecology, (3) environmental protection, (4) resource

management, and (5) eco-development. It fits into the eco-development paradigm, the theory of Sustainable Development, which formalizes the axis of environmental policies in the world.

The productive processes aimed at improving the environment known as "green economy" managed jointly and systemically, including Sustainable Development and mitigation of environmental problems, achieving quality of life and economic-social well-being, are defined as: Environmental Management, (UNEP, 2010). It is interpreted as a mechanism to achieve economic and human development with the rational use of natural resources and protection of the environment.

In a particular way, Massolo (2015), has described it as the set of actions and strategies through which activities are organized to influence the environment, achieving as a result, quality of life, also allowing, warning or weakening problems in the environment , conceptually based on Sustainable Development. Therefore, it aims to achieve the right balance for economic and population growth, the rational use of resources and the protection and conservation of the environment.

Pigretti (2004) affirms that the companies with vision of future consider the Environmental Management as an opportunity to reduce the consumption of raw materials and environmental aspects of their activities, processes and services; It is the guide or work method to be followed to achieve in a first phase and continuously maintain specific behaviors that are aligned with goals, objectives, norms, that contribute to the minimization of environmental risks, promoting social, financial, economic and competitive precision, which present constant changes.

The Environmental Management for the Carchi Prefecture (2017), is a series of activities, strategies and policies, aimed at comprehensively managing the environment of a given territory and thus contribute to its Sustainable Development, In addition, it promotes that the production processes include the realization of basic and applied research, its development and, are participatory, since it must be emphasized that it is transversal to all sectors, and therefore all processes must follow the protocol to generate benefits economical producing cleanly, with preventive strategies applied to processes, products and services.

The productive processes of goods and services, orient their results in the improvement and well-being of life, reducing risks abroad, are also considered as a structure of Environmental Management, translating into economic, social and environmental profitability (Bozinovic, Donoso, Novoa , Simonetti, 2013).

Similarly, Díaz (2015), describes about Environmental Management in individual understanding, which has broad connotations, however, as part of organizational strategies, there are internal and legislative policies to which its operability must adhere; in this way it is a search for environmental action through continuous improvement processes to contribute to best practices and processes, which avoid or minimize environmental impacts.

This relationship of Environmental Management with companies has a close relationship with the organizational structure, planning, procedures, processes and resources that formalize the regulations and business policy, so it is normal to link it to productivity through improvements. In this convergence, quality management systems become important, since they entail environmental protection through strategies and legal assurances and attached to internal improvement policies (Milena, 2013).

An Environmental Management System is that part of the general system of an organization or company that includes the organizational structure, planning of activities, responsibilities, practices, processes, procedures, resources to develop, implement, carry out, review and keep up to date, an established environmental policy (Massolo, 2015).

According to Aguilera and Santana (2017), the implementation of an Environmental Management System in any company, implies the characterization of all those aspects that are producing a significant negative environmental impact and, the procedures that can be carried out to achieve the elimination or minimization of this impact.

Moreno and Chaparro (2008), make a series of differentiations regarding concepts related to the environment; they define Public Environmental Management, as the adoption of global and sectoral environmental policies, through legal norms that allow the application of previously adopted policy definitions and create the institutional

framework that responds to those requirements. Thus, Environmental Policy is conditioned by: (1) political, economic and social context of a place at a given time and, (2) the situation of Environmental Management that prevails in the place and at a given time.

The norms that seek the protection of environmental systems, regulating the management of factors under a global and integrating perspective, are considered by Moreno and Chaparro (2008) as Environmental Legislation.

The importance of defining Environmental Management, lies in the purpose it has, when considering areas such as human or social, economy or profitability and environmental aspects as mitigation or minimization of risks, all of them, channeled by Sustainable Development.

1.3 Sustainability

In 1987, environmental issues were at the center of several events that led to formal discussions worldwide. In these events, the concern of nations was emphasized to include programs in which the concern of annexing them to their productive and social plans without losing sight of economic interests, which is why the objective became to continuously develop policies, legislation, norms and international environmental agreements in favor of economic development (Gómez, 2012).

There are various concepts such as sustainable use, which is based on the use of natural resources in a way that respects functional integrity and regeneration capacity of ecosystems; ecological balance, which is the interdependence between elements of the environment that make the existence, transformation and development of living beings possible, among others, that promote studies that lead to the exercise of public policies in favor of Sustainability (Gutiérrez, 2014) .

Environmental Sustainability It is based on cultural diversity considering plurality, it also enhances nature based on the diversity of ecological values and the preservation of identity, thus considering synergistic and non-economic elements. In this way, it allows to manage the production, since by means of strategies of Sustainability, it will look for that it is diversified and adjusted to the context and ecological potential of the regions (Boiral, 2005).

However, after several conceptual studies about the interpretation of the term, it is considered that Sustainability, even with two important connotations, where it implies the internalization of the ecological conditions in which the economic process is supported and, on the other hand, interpreted as Sustainable, referring to the durability of the economic process itself (Left, 2000), can be renamed as Environmental Sustainability, since this new concept transcends market values by being framed in a policy of diversity and difference, which recognizes and values nature from a plurality of rationalities and identities, also moves away from the productivist conception of the environment, seeking to become a strategy for the social reappropriation of nature, based on the cultural, economic and technological valuation of environmental goods and services, generating a policy of being, of diversity and difference that rethinks the value of natural resources and the meaning of production (Left, 2004).

The World Commission on Environment and Development (1987) defines sustainability as development that meets the needs without compromising the ability of future generations to meet their own needs. One of the origins of Sustainability refers to the Global Compact, proposed by the UN through the Secretary of the United Nations in the World Economic Forum (Gudynas, 2002). Thus, in this decade, Sustainability takes, after the process of consolidation of the environmental movement, great importance, establishing that the management should cover equally the economic, social and environmental concepts (Elkington 1997, cited in Garcia, Portales, Camacho, Arandia, 2010).

Sustainability refers to regulated growth, involving political and social measures, to use natural resources efficiently. It refers then to the development that meets the current needs of human beings without compromising resources (Naredo, 1999). It is part of strategic planning, focusing on ecological and spatial impacts, the latter being (1) supply (water, energy, fuel consumption) and (2) sanitation (solid waste, wastewater, toxic gases). It also considers aspects of the problem, both scientific and ethical, and at the same time contemplates the limits and maximum possible requirements to maintain the standard of living and economic development (Naredo, 2006).

The analysis of these concepts is considered an important link between Sustainability and the need to create policies that support it, as well as a platform for action; From the various definitions, a proper definition is presented for the present investigation:

> *"Sustainability refers to environmental practices supported by Legislation through Regulations, which allow industry and society to guarantee natural resources to future generations; these practices are integrated into the strategic plans of Environmental Management ".*

1.4 Sustainable Development

Sustainable refers to a process that can be maintained on its own; Left (2007) refers to it as: enduring; then rescues that ecological sustainability is constituted in the condition of the sustainability or durability of the process.

The Brundtland Commission, led by UNEP in 1983, to develop schemes that involved economic, social and environmental factors in all productive activities, in addition to promoting the cooperation of industrialized and developing countries, should propose a model with socio-economic and environmental strategies towards 2020; The result was: Nuestro Futuro Común (1986), a document that denotes the political character to solve environmental deterioration with prompt and decisive actions, through arguments of confrontation between economic growth and destruction of the environment (El Serafi, 1994).

Sustainable Development proposes an economic growth that implies: social cohesion, limiting nature of the natural resources and, environmental capacity to assimilate the residues (UN, 1984). It also promotes a balance between economic growth, social justice and the environment; the basis is financial prevention for the elements of remediation, the inclusion of human habits that tend to the equity of consumerism, the creation of services and opportunities and, more efficient production and operation processes (Naredo, 1996).

Zeballos (2016) considers within the implementation of Sustainable Development, three dimensions: a social, an environmental and an economic dimension, also pointing out that it is achieved when these three dimensions act as a whole. Within the environmental dimension, the focus is concentrated on the factors that will

determine the productive capacity in the future: the soil resource, water, plant cover, forests and biodiversity.

Sustainable Development is related to the capacity of a social system to promote natural, local and regional resources without destroying the base on which all activity depends, which creates awareness of the social impact between production and consumption (Benítez, 2019)

Sustainable Development can be interpreted as the guide or route to follow to reach Sustainability, therefore, it refers to the growth and development necessary to reach a sustainable state (Zeballos, 2016). The operative part that Sustainable Development pronounces stands out: it is based on the aspects or productive processes and in addition, it carries intrinsically the structure of how it is achieved (Martínez, Bednarek, Rivera and Ojeda, 2019).

In a broader sense, subject to the concept of sustainable development, sustainable development is about strengths and durability in the economic, ecological, and socially equitable areas, founded on democratic bases, accepted politically, and disseminated through culture (Latouche, 2007).

Objectives of Sustainable Development

By 2015, the United Nations Commission for Sustainable Development is working on the implementation of the Sustainable Development Goals (SDG), which are universal measures to combat poverty and guarantee peace and protection of the environment. They provide goals so that all countries, according to their particular priorities and challenges, can adopt them for the benefit of current and future generations (UNICEF, 2015).

In the face of structural, productivity, segregation, educational, health, gender and technological inequalities, the efforts of the United Nations member countries are channeled into bringing about change and having a positive impact on the most disadvantaged sectors of the planet, thus becoming global challenges. These challenges are described and capitalized on through suggestions for action to confront them and through goals to be achieved in 15 years to counteract this series

of inequalities (International Labor Organization, 2017 – Organización Internacional del trabajo-).

The result of these global efforts around Sustainable Development are expressed in 17 Goals, described in the document called: Agenda 2030, achieving with them that important economies come together to face economic, social and environmental challenges (Martínez and Rivera , 2017). The strategic plan focuses on sectors that comprehensively (economy, society and environment) promote programs to alleviate poverty, democratic governance, consolidation of peace, climate change, disaster risk, economic inequality and care for ecosystems.

The Sustainable Development Goals seek challenges and achievements in countries and at levels that reach these, even small towns, so the commitment becomes complex in extension; Although, this challenge promotes the implementation of actions on the objectives that frame the primary needs of societies, it does not minimize execution through alliances of the rest of them, which focus on productivity and the environment (UN, 2016).

The Sustainable Development Objectives form a system, they are interdependent elements of objectives clearly described through parameters, indicators and goals to be met, which have as a vision, the generation of environments of equality and equity in all parts of the planet, so they become holistic proposals for the reorganization of society in harmony with its environment (AECID, 2017).

Environmental and socio-economic aspects are currently a political-social issue that has forced the economies of both industrialized and developing countries to redefine and expand the law and international organization (Benitez, 2019).

The achievement of the goals of the Sustainable Development Objectives, therefore, requires the collaboration of the government of the countries, the private sector and society to ensure that future generations are secured without neglecting the current ones. This is known as multilevel governance, which addresses the public problems of implementing the Goals, promoting institutions that are constituted under responsible and inclusive parameters through normative and analytical work and development capacities, considering actions for improvement, responsibility, political and social cohesion (Torres, 2018).

Conceptual conclusion

The literary analysis about Sustainability and Sustainable Development, from UN programs, such as UNEP, the Brundtland Commission, some selected references such as: Naredo, Left, Zeballos and, about Environmental Management, for which, authors such as Massolo and the UNEP itself, among others that have provided knowledge about the concepts, originate the referential framework and lead to a series of particular conclusions, which create the literary platform for the research:

- Environmental Management, Sustainability and Sustainable Development are concepts that are closely related, in such a way that they become the driving force behind the doctoral subject that supports this research.

- It is recognized that the population, especially the economically disadvantaged groups, are people with the capacity to maintain a cultural, aesthetic and spiritual relationship with the environment.

- It emphasizes that the use of ecosystems and the species that inhabit them are part of nature, so they should be treated seeking self-renewal that are part of a culture of progress for the quality of life, without limiting economic progress.

- The quality of life, becomes a reflection of the cultural relationship between progress without degrading the environment, this through measures and processes of continuous improvement in their industrial processes and infrastructure development.

The conceptual link that is made is:

Sustainable Development is considered a process of change in which the exploitation of natural resources, the direction of capital, technology, progress and institutional changes are generated with harmony; Garza and Gonzalez (1997) assure that it is necessary to administer the environment and to know the laws of nature that allow to learn the respect by the same one.

Sustainability, on the other hand, includes aspects such as systems management, with a conception of equitable systems in terms of the distribution of areas, goods and local decision-making power (Enkerlin, 1997, quoted in Reyes, 2019).

For the purposes of this research, Sustainable Development is the operative part, they are objectives, goals and activities structured as tangible proposals; It is a guide that systematically follows guidelines to prevent deterioration of the environment. Sustainability, for its part, refers to the generation of policies and strategies to pursue and allow the operation of Sustainable Development; it is intrinsically aligned with the axes of Environmental Management (Martínez, Bednarek, Rivera, Ojeda, 2019).

In this way, an important triangulation is obtained, since *Environmental Management covers Sustainability through strategic planning, where the programs that give opening and platform to Sustainable Development are attached* (Martínez, Bednarek, Rivera, Ojeda, 2019).

2. Contextual Framework: Mining-metallugical Industry

The needs of the world's population have increased and, by the end of the 20th century, have reflected a strong impact on natural ecosystems. Mining has proven to be a basic activity in the search to satisfy those needs, since the extraction of precious metals, in its beginnings, became an integrated activity, recognized today as a mining-metallurgical industry, since the mineral resources required an industrial transformation to be used (Saavedra and Sanchez, 2007).

The development of the society is measured based on the use of the own or imported resources and the economic spill that is paid by them in its diverse stages of use and process; the minerals represent in great scale, the bases on which the processes of products and services are made, in addition that they comprise fundamental part of the raw material in their diverse presentations: metals, non metals, alloys, fuels, etc. (Herrera, 2006).

In this way, the mining industry participates in the market as a supplier of metals and non-metals for the manufacturing and construction industries, contributing to the production of mineral-based goods; Mining units are part of various industrial production chains, since they provide metallic and non-metallic minerals in their natural state and concentrates, other establishments consume these minerals and

carry out the smelting or refining of metals, generating rolled products, slabs and other basic metallic products These products are later transformed into various ferrous and non-ferrous metal products (INEGI, 2011).

In the history of mankind, facts are always considered that base their existence on mineral evidence, from ornaments to the beginning of industries and the foundation of civilizations; the use of minerals is very extensive and at the same time unknown, there are advances in science, such as health, based on metals and the application in high technology of both non-metals and metals in the agro-industrial, textile, and automotive industries, is incalculable and invaluable; it is stated that without minerals, life would not be as we know it (Arvadinitis, 2014).

The Mining Industry and the use of resources are in an operational context in which the future of technological, social and environmental development that society demands today must be ensured. The work environment deserves significant analysis subject to the proximity of its characteristics, since the application of criteria of reliability and rigor should set out precise trends that guide the evolution of this industrial area (Oxfam America, 2004).

Extracting mineral resources requires development infrastructure, which involves, in addition to the territory occupied by mining estates and mineral processing plants, a territory where to accumulate production residues (Melo, 2011). Therefore, this infrastructure has a great impact on society, assuming disinterest in what is caused to the environment.

Despite being an industrial sector that strengthens nations in the face of their position in investments and local and economic growth, Mining has, through history, presented various legal and societal problems that to a greater extent are of the environmental type (Lowrie, 1997). Despite its importance as an economic factor and the participation of the industry in relation to the Gross Domestic Product of the nations, which is evidence of representative income in their economy, this generation of profits and profits is not reflected in investment to recover resources exploited natural resources (Espinoza, Hernández and Mantilla, 2016).

2.1 Mining-metallurgical Sector

This industrial sector encompasses industrial activities that by means of obtaining geo-resources, society is supplied with raw materials. These activities are generalized as land preparation, mineral extraction through drilling, explosions, debris, loading and transportation, the process and management of tailings and gangue (SEMARNAT, 2016).

As a science, it is a set of knowledge related to methods, systems, techniques, processes, equipment and instruments that make it possible to extract minerals to obtain products, raw materials and energy, according to specifications and based on economic criteria (Pla Oritz, 1994).

It also covers different areas, such as earth sciences (Geology), design and operation of exploitations (Mining), mineral treatment (Metallurgy) and, natural sciences (Ecology). Thus, the mining-metallurgical sector ranges from exploration and research to the commercialization of products made based on minerals, through the exploitation and environmental restoration of the area that was impacted (AIME, 2000).

The value and grade of the ore, size, shape, depth, location of the ore body or deposit, physical-chemical properties, environmental conditions of the exploitation area, environmental impact of the operation, geological, hydrogeological, geochemical conditions of the rocks, seismic and particular conditions of the land or area (biotic and abiotic aspects), availability or use of soil, variable infrastructure (financial, permits, taxes, investment, compensation, operating costs); safe working conditions, recovery fraction of the mineral value, operation continuity and productivity among many other factors and elements, which are derived and described after in-depth technical studies of a given project, are those that condition or provide the information that must be gathered to decide if the studied unit will have a type of subway mine or open pit mine (SEMARNAT, 2016).

The processes or stages covered by the mining industry, according to the General Coordination of Mining (2014) are

- Exploration: areas of interest are recognized, in order to confirm the physical and chemical characteristics that show that the mineral deposits exist. It

includes regional prospecting, which is the discovery of indications, small closed and open mines without significant production. The purpose is to establish and calculate mineral ore reserves or ore deposits, location and characteristics of the deposits or ore deposits, elaboration of the mining plan, means and methods of exploitation and feasible duration of the expected production (ANM, 2000).

- *Exploitation*: work designed to prepare and develop the area where there are mineral deposits, as well as activities aimed at extracting these minerals or substances from nature. Special equipment is used to drill large holes in mineralized zones, whose holes are filled with explosives, which remove large volumes of material that must be extracted from the exterior (INACAP, 2001).

- *Mineral benefit (metallurgy):* preparation and treatment, smelting, concentration and refining of extracted mineral products, in order to recover minerals and substances in terms of purity (separation). Once there are banks of mineral extracted from the mines, using rock crushing methods, quantities of the mineral with value are separated from that mineral of low or no value (sterile material). Crushing or grinding is one of the most expensive activities in the mill; It also includes physical / chemical separation techniques such as gravity concentration, magnetic, electrostatic separation, flotation, solvent extraction, electrolysis, leaching, precipitation, amalgamation, etc. The waste from these processes, their management and final disposal, deserve special attention due to their nature (CFI-GBM, 2007).

- *Closing*: once the mining-metallurgical operation is finished, the closure must be strategically planned, with the vision of reintegrating the used property to its natural or urban environment, which is considered as a rehabilitation goal. They should contemplate strategic rehabilitation and closure plans that describe how the company will restore the site to the closest natural condition possible, how it will prevent the release of contaminants from the various facilities, and how it will allocate funds to ensure the expense incurred. due to closure (ELAW, 2010).

The research is developed from the knowledge of the activities of each stage of this industrial process (Martínez, Bednarek, Rivera and Ojeda, 2019).

2.1.1 Underground Mine

They are made up of galleries or tunnels at depths below the ground surface. The exploitation of a mineral by means of underground mining is considered when its extraction at the surface level is not possible mainly due to economic, social or environmental arguments. It can be divided into two depending on the type of rock in which it is worked: soft rock mining and hard rock mining (Monreal and Hernández, 2015). Soft rock is considered this way, as it does not require the use of explosives during the extraction process. For its part, hard rock does require the use of explosives as part of its extraction.

In order to access the mine it is necessary to excavate and form tunnels or access galleries, these usually surround the site, so they can be very extensive, this process is known as: development. Extracting the mineral is called: tumbe, the choice of method depends on the shape and orientation of the deposit. The machinery used in subway mining is much smaller than that of surface extraction, because the tunnels and other works are performed in small spaces (Monreal and Hernandez, 2015).

The work inside requires special infrastructure generally composed of an access shaft (vertical shaft, ramp, inclined plane, etc.), general plants, galleries (transit of personnel and movement of equipment and mineral), communication wells between plants and farms, forming a whole that allows ventilation circuits (LOM, 2015).

It is considered due to its extraction process of greater risk, therefore it is valued to consider superficial extraction. The facilities for mineral extraction vary depending on the type of extraction, being also in this case, the most complex underground exploitation (Fierro, 2012).

The underground exploitation methods are selected by knowing the morphology of the mineral, for this, geotechnical studies and rock mechanics are required; Based on the methods, variants are considered for the design, horizontal or vertical or combinations. Stability is a fundamental element to consider for design (Garay, 2013).

2.1.2 Open pit mine

Open pit mining consists of the execution of extractive activities of economically valuable material, using techniques such as digging wells and pits on the surface of the earth where there are important deposits of the material to be extracted (Morán, 2013). This form of extraction, expanded in the 70's and current decade.
When the rock is removed from the slopes of a hill, the mineral deposit is located on slopes, when the rock is removed from a certain depth from ground level, the deposit is in pits. For its exploitation, dynamite and crushing machinery are used, which occupy reduced spaces, located at levels below the upper edges of the exploration; noise is minimized when there are wooded areas around, since a screen effect is generated (Franklin and Maurice, 1991).

The excavation, once dynamited, uses heavy machinery to remove debris and recover valuable material, which is transported by truck to the processing plant or leach pads. The soil that has been removed is stored in piles for separation; also, the sterile material is stacked for later use in landfills, called restoration (Price, 1997).

This method is more economical and faster extraction of ore, however it produces more waste rock and dust and landscape devastation, coupled with the consumption of large amounts of water (Giarracca, 2010).

There are four elements to be considered in open pit mining to minimize risks of environmental impacts (Correa, 2000): (1) geographic location, having to detail with exactitude the place of extraction and the relationship with neighbors, (2) treatment of the material, measuring noise, vibration (transversal and longitudinal), (3) landscape, the changes in it, produce in the physiography, impacts that are translated in negative aesthetics (transformation of volumes, movement of earth, stripping, loss of vegetation and ground, increase of erosion) and, (4) vegetation, allowing to select adaptable species to the climate, considering meteorological data (precipitation, temperature, humidity, radiation, wind).

2.1.3 Metallurgy

The part of Metallurgy within the industry being studied includes: (1) obtaining the metal from the mineral that is extracted from the deposit, from which the sterile

material is removed, (2) purification, in which it is eliminate impurities that could remain embedded in the metal, (3) the manufacture of alloys, (4) various treatments of the metal to facilitate its subsequent use and (5) various physical-chemical treatments: crushing, grinding, filtering (pressure or vacuum), centrifugation, decanting, flotation, dissolution, distillation, drying and precipitation; roasting, oxidation, reduction, hydrometallurgy, electrolysis, hydrolysis, leaching through acid-base reactions, chemical precipitation, electrodeposition and cyanidation (Monreal and Hernández, 2015).

Metallurgy begins as a process in mining extraction units, where as a final product concentrates of the metallic or non-metallic mineral that are being exploited are obtained, therefore it must begin its separation process (Call and Savelly, 1990).

One of the most common treatments, due to the economic factor, is Flotation, which consists in that the material with the mineral of high economic value is crushed, ground and poured into water with reagents (detergent and oil). This mixture produces a foam that selectively drags the mineral particles to its surface, leaving the material sterile or that does not have a high economic value. This method can also be used due to the magnetic properties of minerals, using magnets that attract the minerals and leave the gangue on one side (CODELCO, 2018).

Another method of separation is the use of amalgams, that is, alloys of mercury with other metals. This is generated by dissolving gold or silver contained in the mineral to form the liquid amalgam, which is easily separated from the rest of the mineral. This method was widely used to separate gold and silver. Gravity separation is one of the simplest and most economical methods, since it uses the difference in densities between metals and metallic compounds and the rest of the material with which they are accompanied in the rock; the crushed mineral is suspended in water or air jet, the heavier particles (metals) falling to the bottom (Lang, 1999).

Leaching is one of the relatively new hydrometallurgical recovery processes in the mining sector and one of the most widely used. In this process a pulverized substance is dissolved in order to extract soluble parts from it. The water is used as a means of transportation, the use of chemicals helps to separate valuable ore from uneconomical ore (López and Pérez, 2018).

From the metallurgical processes, as well as the mineral benefit processes, which in general terms can be considered equivalent, toxic wastes result that force an increase in environmental policies. These must include effective methodologies to evaluate materials and waste that are subject to regulations (Fowler and Goering, 1991).

2.1.4 Refinery

The Refineries are large metallurgical companies that receive mineral concentrates from various mining extraction units. In general, its main product is delivered with very high purity, having during the process, obtained minerals that due to their quantity and value in the market, are considered by-products. For this reason, since there are several types of mineral that must be separated or joined, when it comes to alloys, in a Refinery, it is common for several types of treatments to be carried out (Romo, 2011).

Refining as a process requires strong capital investment, since technological complexity and environmental regulations are fundamental. Its construction consists of several continuous production plants. It is an industrial fraction, however, its relevance and importance make it a strategic economic element for some countries (Romo, 2016).

Refining is necessary to obtain isolated metals with a high degree of purity that makes them suitable for manufacturing and industrialization processes. It can be carried out through three procedures: (1) pyro metallurgy, use of furnaces in which the impure metal is separated by fusion and oxidation, (2) electrolysis, by means of electricity, the impure metal is ionized in an acidic medium, and (3) hydrometallurgy, which is leaching by chemical means (Monreal and Hernández, 2015).

The effects that a refinery can have on the environment may be on natural resources: water, since the use of this liquid is fundamental in the process and, as historical data describe it, its waste that is thrown into rivers, lakes, dams. In addition, a product of obsolete equipment and technology, polluting gas emissions can be perceived miles away from work units. Spills being the problems that have most impacted the environment, the refineries experience strong socio-political problems caused by the destruction of the environment (UN, 1990).

2.2 Mining-Metallic Industry

The mining industry is an important activity both in accounting for foreign exchange income, as well as for the participation in the production chain of various industries dedicated to the transformation and handling of minerals, metallurgical, iron and steel and metalworking industries; the chemical industry, construction, and several others (Crispín and Sánchez, 1992).

In the mining industry, the extraction of precious metals: gold and silver predominates in the value of total mining production since the 1980s, however, there are important figures regarding the extraction of other non-ferrous metals, iron and steel and even various non-metallic (SE-SGM, 2017).

The mining-metallic industry is often located in places that are difficult to access and far from the city. The elements that make up the metallic deposits, the conditions of the physical environment, the population, the infrastructure and the equipment for public use, are aspects that define the mining capital to be established (Osorio, 2004).

Due to its location, it is required the construction of roads, electrical installations, water supply systems, construction of waste dams (tailings dams), etc., activities that are also assigned to the development stage of the exploitation; in addition, it must be considered if the mine will be open pit or subway, to consider the transportation of the mineral to the processing plant and then, as a concentrate to transport it to a distribution port (export), customer or refinery (González, 2019). By their nature, the places where a mine is located, restrict the settlement of populations and other activities in very close areas, considering also, environmental aspects not suitable.

2.2.1 Metallic Mineral

Numerous metals, such as gold, silver, iron, copper, lead, mercury, etc., have actively participated in the founding of civilizations throughout the history of humanity; its provisioning was the priority of ancient man. Based on metallic minerals, tillage arises, that is, the exploitation of the mineral resource and later acquires value and economic importance and with this, extraction methods were emerging. The places that had deposits of metallic mineral, took importance in profitability and strengthened economic position (Oyangüren, De la Cuadra, Huerta, Grijalbo, 1984).

The metallic mineral or metal, is an inorganic chemical compound that occurs naturally with a chemically precise composition and that has physical properties that set it apart. They can be grouped as follows (Flores, 2019):

- Precious metals: gold, silver, platinum
- Basic metals: copper, lead, zinc, tin
- Steel metals: iron, nickel, chromium, manganese, molybdenum, wolfranium, vanadium.
- Light metals: aluminum, magnesium
- Electronic metals: cadmium, bismuth, germanium
- Radioactive metals: uranium, radio.

All of them are found in deposits that after extraction and treatment are used for raw materials from various industries. Oyangüren (1981) describes that the exploitation of metals attends to their presentation in the natural mantles that contain them:

-Pilons, cracks, fissures, fractures or plane faults: rocky massifs filled by precipitation of minerals in solution or by injection of magma minerals. They have varied slopes, close to vertical; its powers are oscillatory and its length can be kilometers.

-Masses, bags or lentils: deposits with lenticular shape in which the potency is of considerable size and decreases until it disappears.

-Tabular, stratiform, layer seams: mineralized in the stratification or are seams coinciding with it.

A concept that allows to value the quality of each metal, is the denominated "grade", that is the percentage in weight contained by ton of mineral, although its form to vombine in its minerals is varied; the importance of the grade radic in which the value of the recovered metal is the paid one to cover expenses of mine, preparation and smelting of the ore, plus the benefit. It is an indicator that marks the limit until the decision of being a profitable deposit (Jaeger, 1969).

2.2.3 Silver

Shiny white metallic mineral, considered the best conductor of heat and electricity; it combines easily with other metals, managing with it, industrially valuable alloys, the best known with Copper, providing it with specific hardness that is used in jewelry, coins and other objects of goldsmithing. In nature it is accompanied by other minerals, so its extraction is through mining-metallurgical processes. It is valued in the main world markets, thus earning its price (Sociedad Nacional de Minería, Petróleo y Energía, 2012).

It is called Sterling Silver when the precious metal presents the minimum quantity fixed by the current legislation, it is read in thousandths, to avoid deceiving other jewelry products, which contain less quantity of silver; this is how 999, 925 and 800 thousandths silver are known, marked on the product, which represents its Law, also translated as quality of the metal (Temporary Museum Exhibition, 1989).

Mexico has been for several years the main silver producer in the world, in 2015 its production value reached 417 thousand million pesos (SE-SGM, 2017). It is exported in semi-manufactured form, in raw form, in metal plating and powder (SE-CGM, 2017); between 2005 and 2013, 80% of the national production was exported in concentrate to China and Germany, then South Korea and China were the main buyers, reaching 90% of the silver ore concentrate.

Silver keeps Mexico as the main seller of jewelry and silverware in the world; as a jewelry producer, it occupies the fourth place only after India, Italy and Thailand. The main buyer of Mexican silver is the United States, followed by Germany, Great Britain and Japan. The main silver-producing states in Mexico are Zacatecas, Durango and Chihuahua; extraction and processing are also concentrated in Coahuila, Guanajuato, Guerrero, Hidalgo, Jalisco, the State of Mexico, Querétaro, Sinaloa, Sonora and San Luis Potosí (Clausell, 2010).

2.3 Environmental Impacts

Environmental impacts refer to adverse effects on ecosystems, climate and society, they can be caused by activities of extractive processes, use and deposit of hazardous waste, emission of pollutants into the atmosphere, water, soil and, change

of land use. Classified as direct or indirect according to the secondary effects they cause, they are also studied based on three dimensions: magnitude, importance and significance (Perevochtchikova, 2013).

According to André (2004), magnitude refers to the spatial extension, number of people or communities affected, duration, danger of the actions carried out or substances released; importance is directed towards affecting the objective of protecting life, health or ecological balance and, significance, is channeled to affecting species, area characteristics and the vulnerability of the danger they are in.

De la Maza (2007), describes the environmental impacts, the character, which defines the meaning of the change produced by an action of the project on the environment, also dividing them into: (1) beneficial or positive impact, (2) harmful or negative impact, (3) neutral impact and (4) foreseeable impact. It also states that they are rated according to their magnitude, and expressed as percentages; it also measures them according to human significance, through levels of importance and certainty.

The environmental impacts can be considered as effects of the actions of a project, in which the term to be manifested is described according to evolution studies, the duration that it will have, being able to be temporary or permanent and if these effects are reversible or irreversible (De la Maza, 2001).

The classification and division of the impacts, derives in qualitative and quantitative methods that measure or evaluate each project, in order to describe it in detail and present actions to be able to reverse, restore or remedy the environment as the case may be (Coneza, 1993).

It arises from the environmental impacts, the Environmental Impact Assessment, which formalizes a tool that seeks to avoid or eliminate environmental effects by human intervention. Estimating environmental impacts provides opportunities to identify unwanted effects and avoid high restoration costs. These estimation studies also quantify social gains and losses, in addition to those impacts on social structures and natural resources that cannot be valued, which is why they are presented in approximations in a quantitative format (Rau, 1980).

2.3.1 Environmental impacts of mining processes

Mining activity can generate substantial changes in the relief, modifying the geological structure as a result of exploitation, it can cause destruction of the soil or degrade it, in addition, both surface and underground water resources can suffer alterations; the biological environment can be partially or completely destroyed during operations (Arranz, 2015).

SEMARNAT (2016) describes the possible impacts by stages of the sector's process: the extraction stage can destroy the orography, flora and fauna, in addition to generating dust and particles and during explosions, combustion gases; underground mine vents emit solid particles containing metals; liquid emissions of waste, there are also remains of compounds due to the use of reagents and / or inputs in the extraction and beneficiation process.

There is generation of combustion gases derived from engines inside and outside the mine, explosives residues. For the benefit of the mineral, combustion gases are generated, and the use of water that mitigates dust emissions will drag particles to the ground, especially if it is dry operations (SEMARNAT, 2016).

The landscape can suffer modifications, some of them severe, so much so that by their perception, authors such as Tandy (1979), point out that mining impacts are more aggressive than any other human activity.

The risks of environmental impact by mining activities are the combination of the probability of occurrence of an event and the magnitude of its consequence. A risk of lesser magnitude is an event with a low probability of occurrence and negligible consequences, while a risk of greater magnitude has a high probability of occurrence and a catastrophic consequence. The literature that contemplates the impact of the mining industry is usually very broad, inquisitive and directed mainly to the liabilities that generate degradation of old mining operations (Estevan, 1984).

Thus, the impact can be known as loss, soil contamination, change in morphology; the risks can be landslides, flooding, erosion, difficulties in transit and others (Gilliland and Risser, 1977).

2.3.2 Mining Environmental Liabilities

Environmental impacts generated by abandoned mining operations or in units where there has not been a regulated mine closure certified by corresponding authorities are known as Mining Environmental Liabilities (MEL); these represent significant or permanent and potential risks (Oblaser and Chaparro, 2008).

SEMARNAT (2014), defines MAPs as contaminated sites by the release of hazardous materials or waste that were not remedied in a timely manner to prevent the spread of contaminants, but imply a remediation obligation.

Mining MELs are usually installations, buildings, surfaces affected by spills, deposits of mining waste, stretches of disturbed channels, workshop areas, machinery or mineral yards (Arranz, 2008); These may, depending on their characteristics and those of the context, be a risk of environmental impact.

In addition to impacting the environment, MELs can pose risks to human health, due to the presence of toxic substances; great social problems are based on individual, group and neighboring community demands, which manifest illnesses caused by MELs (Polo, 2006).

The most obvious impacts occur in the mine areas proper, however the contiguous and even very remote areas are usually in sources of contamination to a greater or lesser extent. Activities may be affected by the residues from the farms, liquids and solids from the discharges by the beneficiation plants, residues from metallurgical extraction and refining plants, inadequate waste management, MEL, etc. (Rodríguez and García, 2006).

2.3.3 Abandoned mining

Throughout history, the impact that old or abandoned mining has produced has been a world reference for damages generated in various places: land with no destination or owner, holes that can become traps, aquifers, rivers and contaminated soils, land susceptible to breaking or eroding, destroyed landscapes (Arranz, 2008).

Between active mining and abandoned mining, the biggest difference is that the assignment of responsibilities is uneven, being an obstacle for the programs, plans,

authorities and agencies involved, defining the distribution of these between land owners, government agencies, business groups, former beneficiaries and others (Nero, 2005).

The actions to be carried out to restore are the same as those described in the closure plans, however, the cost has to be absorbed by the state, so in many cases, the only way of rehabilitation is re-activation. of exploitation when minerals have value (Balkau, 1999).

The remediation or rehabilitation also includes the so-called "Abandoned Mining Plans", which includes analysis of existing scientific-technical documentation, budget items, inventories, relationship with government agencies, field visits, official reports, expert interpretation, environmental assessment (Bascones and Gallego, 1993).

2.3.4 Units closure

Operation in the mining industry can last for decades, accumulating waste (tailings dams) and extracted sterile material (earths or mounds) long after operations are closed. Sometimes these do not represent a danger to the environment because they do not contain toxic substances, so during closure, in the case of waste, the dam should be drained, the surface flattened and then covered with soil and vegetation and, in respect to the mounds, they should be removed for use in landfill, construction or other uses, avoiding damage to the landscape; on the other hand, if these wastes are considered to be environmental risks, measures should be taken to focus on their stabilization, also reducing the need for monitoring (Hustrulid, 1982).

When the closing date of a mining unit is stipulated, it should be considered that a re-opening is possible in subsequent years, so it is common for waste to be deposited in an accessible way, since the unit can recover value through new deposits. of minerals, new exploitation techniques or recovery (benefit), even solvency of economic, legal or environmental events (Bref, 2009).

The aspects that must be followed promptly in a mining unit closure are: (1) physical stability of the constructions, (2) chemical stability of waste and sterile material, and (3) future use of the land (SEMARNAT, 2016).

The tailing dams must be prepared for uncontrollable events such as earthquakes, floods and other less drastic but equally destructive as the erosion of air and water, both sterile material and waste, may contain sulfides, causing acid drainage, which must be treated even in operation, because if these are discharged and the water level drops, this phenomenon allows the oxygen in the air to react with the sulfides (Rosa, 2005).

The site occupied by the unit, which presents acid drainage, with high metal or sand content, those not suitable for retaining nutrients or water, hinder works at closure such as reforestation (Pacheco, 2006).

2.3.4.1 Closure plans for mining units

At the end of operations, the mining company, government and society must take measures to protect the safety of people and the environment from harmful effects. Closure planning involves integrating the entire area of the mine into the closure design, establishing timelines, and considering disposal techniques and methods and social aspect economic activities (Sanchez, 2014).

This planning is an instrument of Environmental Management that comprises technical and legal actions to be carried out and that guarantee that the objectives of remediation described in it, are effective; in its strategy, it includes the rehabilitation of the areas impacted by the mining activity, having to reach characteristics of ecosystem compatible with healthy environments for the development of life and conservation of the landscape (Chávez, 2015).

Barettino, Arranz and Martínez (1998), affirm that the closure plans, in addition to the rehabilitation, contemplate activities concentrated in various programs of: restoration (activities to return altered land to its original state), reform (activities that managed to approach the original composition), rehabilitation (activities so that an appearance is acquired according to a previous plan, ecologically stable and the landscape is adapted) and, remediation (refers to the withdrawal, reduction or neutralization of substances, waste, materials, in order to prevent adverse effects on the environment.

Closure plans are intended to conserve, improve, recover and rehabilitate to provide another use to the resources, ecosystems or landscapes, this requires the

intervention of agencies that assess the damage and promote programs or direct or indirect activities for proper remediation, these agencies will also be responsible for monitoring these plans. Systematically, closure plans describe the appropriate programs: restoration, reformation, rehabilitation or remediation. The companies will try to resolve the most urgent issues in a context of economic and material means, and then continue with a previous list of established priorities (Escudero and Martinez, 1998).

Thus, a closure mining plan or even an abandoned mine, is a general scheme of actions to be carried out to carry out within its Environmental Management strategy in a certain territory: analysis of scientific-technical documentation, analysis of convenience of budget items to sample, characterize through field and laboratory teams, contact with organizations, agencies or investors, design of field files and verification of validity of the terrain design, field visits to obtain inventories, delimitation of inventory elements on cartography , information analysis to interpret analytical data, environmental assessment, edition of results and conclusions (Falé, Henriques, Midoes, Carvalho, 2006).

Contextual conclusion

It is contemplated within this theoretical framework, the general bases for the reader to be placed in a significant context for Mexico, the information more than data that support the economic sector, aims to describe the process and how this in its exclusive facets, has different types of units that adhere to regulations but there are others that outside the legal framework operate. It is therefore important to establish environmental strategies that promote practices that help the public and private service to regulate this type of actions that only harm the environment.

That the reader has an overview of how the Mining-Metallurgical Industry of Mexico is formed, will allow him to understand the state of environmental emergency that lives and how also, the authorities seek to improve the platform to eradicate and minimize the environmental impact. Likewise, it will be in a position to reflect on the literary origin of the Model that is presented, because its foundation must face the culture of the Mexican, which in its denomination is creative, spontaneous, warm and with a great sense of labor expression, which represents as belonging and loyalty to organizations from which it obtains sustenance and , these on the other hand, provide

legal aspects that guarantee safety, quality, professional and personal growth and harmonious work environments and those that concern the environment.

3. Reference Framework: foreing operating models in Mexico

There are documented in this section a series of foreign models-programs that although once they have been implemented with relative success, their continuity is intermittent over time and their effectiveness is low or no. One of the reliable reasons for this phenomenon refers to the imposition of these in a medium of sense of belonging originated in the idiosyncrasy of the Mexican (Martínez, 1998).

The success of foreign programs in Mexico implemented in the business sectors, is disseminated with excitement and both individual and team recognitions and even international certifications for the organization are received. These models and /or programs are cataloged in the different departments that make up the unit (human resources, operation, security, environmental) being participants in each of the members of these and, in those that concern the entire unit, they are known as Systems, which allude to the organization from the general authority commands (owners, corporacines, investors, stock exchange) to those external members, such as customers and suppliers, thereby becoming adherents to these certifications so desired for the merit that they give to the image before the competition and consumer society (Martínez, 2018).

3.1 Administrative programs

Foreign administrative programs are those that every Mexican company expresses a need to implement; this is due to the pressure of the international markets of developed countries that, for decades have made use of emerging economies, among which Mexico for its skilled labor force and certification system of labor skills, as well as the large territory that owns diverse and abundant natural resources, is an important part of , in addition, national competition and the same consumer society of the modern era (Martínez, 2018).

These programs generally promote the harmony of the environment, which will provide a sense of belonging and motivation to the members of the organization, thus

inciting favorable productivity measures that will also start in profitability (Molinari, 2018).

Exemplifying this position, some of these models-programs and their generals are mentioned, it is worth mentioning that it is the area where more programs and models are gestated:

- *Leadership programs:* conducted by staff outside the organization, usually by an expert consulting firm that provides prestige and neutral benchmarks. Directed mainly to personnel with authority and command post and algnas times intermediate headquarters; they are expressed with recognitions by the firm that leads and sometimes they are endorsed by the Ministry of Public Education and the endorsement of their own labor skills programs. The decades of the 80's and 90's in the business field lives a boom in the development of these programs, obtaining better productive results in the short term, however, the acceptance that with the rest of the employees is perceived, is not as expected and consequently, the results of having leaders in the organization presented a tendency within the departments and reflections below expectations in productivity indicators in the medium and long term. Nowadays, they are carried out in a more inclusive way, and called "Skills Development" or "Human Development", which do cover all the personnel of the organization (Martínez, 1998).

- *Induction Programs:* Subjects of various researches, induction programs, start from sociological theories that measure belonging; in order to provide creative and warm welcome to new employees, companies have established protocols with conscious stages of design, execution and evaluation, called "socialization" tmabiñen; the managers and owners of these programs express that they are necessary to adapt and adjust the new employee to the policy and organizational culture, and receive gratitude and sense of belonging and therefore, high indicators of productivity, since for this, it was necessary to make investment that must be repaid. However, it is documented that after receiving a dose of motivation, these programs lose validity due to the non-continuity of the individual's valorization, since this dose is unique, even presenting mood imbalances in the working days and psychological and social

ravages. However, which are classified as obsoleetos and outdated, these programs prevail in the organizational culture of Mexican companies, being obejtos of study of belonging, questioning more and more human capital investigaters if people belong to the organization or, the organization has its foundation in people (Bermúdez, 2011).

- *Mentoring, Coaching:* These programs are implemented in the Mexican culture under the precept of worker failure. In order to avoid high rates of turnover, dismissal and other efficiency, a companion is indicated for that individual who, in the light of the rest and his own, has failed in his work performance. This imposition, although successful in those cases where the individual is an apprentice, such as interns, auxiiliares, practitioners, has not yielded quantified data that position companies in high productive ranks by merit of these, rather, the company of the expert makes personal space and social development uncomfortable, as well as fractures the learning curve of the accompanied. Its boom in the country dates back to the next few years of the opening, without really considering continuity (Martínez, 1998).

3.2 Operational programs

The operation in Mexican companies has in its history, important achievements. Within the Mining Industry, Mexico in colonial times, created through the activities of indigenous workers the "patio system" [patio system], which is exported to Europe and Latin America and is still in force after five centuries (Monreal and Hernandez, 2014). However, obeying the same premises of pressure of international competitiveness and quality, a series of programs have been implemented in order to "teach" them to carry out their activities at all levels of workers, weakening the motivation and creativity so valued of Mexicans.

- *Reengineering,*Outsourcing. Operational-administrative processes that directly value the individual in his abilities and punish him by not presenting favorable performance indications, assigning value to the processes and not to human capital. This punishment, although it is the dismissal of the workers in its extreme, coexists with the protection of the financial programs in Mexico, in which the demarcation of the company's workers rests, opting for

subcontracts to avoid certain taxes. The economic and social damage that these programs brought to Mexican society prevail over the benefits they provided. Its introduction in the country dates back to 1990 and those of Otusourcing are still in force, although diverse groups still fight for new public policies that regulate and / or eradicate them, in terms of Reengineering, it is a program that did not manage to spread in the industrial sector (García, 2019).

3.3 Quality programs

The history of Quality in the world goes back to thinkers, usually of Asian culture, who by 1950 through their business contributions, modified the consciousness of the world of work in terms of qualities of product, process, materials, human capital and, evolve according to the Continuous Improvement Model that Deming proposes. With a series of contributions, this model has been the subject of multiple interventions, however, the International Organization for Standardization (ISO), absorbs it as a fundamental axis of its vision and remains in force. They are precisely those that are exposed below, models and programs that revolve around the Continuous Improvement:

- *Quality circles:* Program that based on observations raises the possibility of improving products, processes, material and any event or circumstance that a formally integrated multidisciplinary team accepts. They often obey contests to encourage employee creativity and participation, making them awarded significant prizes (usually basic or recreational products or services) when these are valued as the best participation. Although the acceptance was eminent and the intention still persists, the members had to give up their personal time without remuneration for the development of their prpyectos, a condition that oversathed the worker, and opts for the non-participation, because in addition, these must in essence, be volunteers.

- 5´s of order and cleanliness. Program of audits that ensure that each of the employees strives for their workplace in harmony, promoting the order of the ersonal and work insturmentos, maintenance of tools and equipment, personal and spatial hygiene, which provides the work environment, cordiality and safe work spaces. Fragmented into steps that amount to simple activities that

accumulate for each evaluation, the 5 s's come from stages of Japanese culture, where the essence lies in the discipline. Its implementation also led to the awarding of departments and people who were managing to climb at each stage. Durnate the decade of the 90's, had a paticular boom, however the last minute work in function of the evaluation, hindered the sense of instilling discipline in people. It is not an existing programme.

- *ISO 9000*: Called ISO family, since from the 9000 standard, there are editions that have as their purpose the standardization of the area, process, service or defined product, in reference to quality and quality management by means of elements sdefined for assurance. Its introduction in Mexico, was in the 90s, its function is an operational success in Mexico, basically every organization, governmental, commercial, business, educational, are governed by its structure and seek and maintain the certification they provide to remain in the market in terms of competitiveness and reflection of doing things with quality. The criticism received from the beginning and until the present days, focuses on the non-discipline that is had as a culture, which does not adhere to the criteria of transcending as being, which is the intention of these norms attached to philosophies for life. The Mexican, belongs to a very independent culture, with foundations, uses and rigid costurmbres, of spontaneous human warmth and creatia, that in spaces of freedom and conviction, provides potential and capacity above what was expected, but in areas of pressure and exercise of ocmrpomiso or obligation, his acittud decreases and his productivity is diminished. Although ISO due to international pressure, it is still in force, the acpetación has never been toal and its execution is partially fulfilled, since the natural creativity makes that hours before the uditorias of evaluation of the quality system, the worker fixes any discrepancy between his work and the description of this, achieving that the faults are not perceptible to those who serve as auditors (Buenaventura, Villegas and Edison, 2007).

3.4 Security Programs

To safeguard integrity and people, programs based on security have always been innovative, and although the objective is always the same, they receive names alluding to their purpose. These establish specific procedures or sequence of

operations aimed at preventing and reducing losses arising from occupational risks. Usually also linked to the issues of hygiene and occupational health.

- *Our next step to zero, zero tolerance*: programs implemented based on the accident rate, force staff to act with caution at all times, restrict areas, equipment depending on care. Operative effect arises, but they press and the concentration of the employee is usually not based on the risk, but on the non-compliance that leads to a punishment.

- *Audits, inspections:* objective evaluations to establish adequate conditions in the workplace, so that their application is reflected in productivity indicators. They are usually endorsed by legislation, which has defined and substantiated procedures.

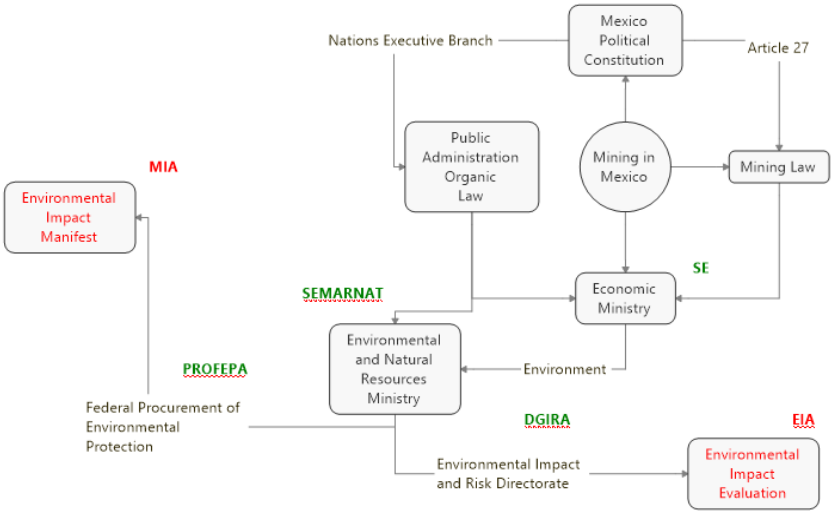
3.5. Environmental programs

There are numerous conservation programs which are aimed at the remediation of the environment; these have great reflection in society, but continuity remains a negative factor within Mexican culture. This being the central theme that is developed in this research, two models are considered that serve as a subject of comparison and complement to the proposed Model: the ISO14000 Standard and the National Model, which is based on regulations and is very extensive in its application, evaluation and monitoring:

- *ISO14000 Standard:* A fundamental part of the ISO family, its purpose is the standardization of an environmental management system. It is based on Continuous Improvement and follows the documentary dynamics of process procedures like the rest of the ISO family. Numerous studies conclude that they are a form of taxation of production mechanisms distributed inland and environment constituting technical barriers that ensure segmented controls in various companies, mainly in those that belong to or have their origin in countries with developed economies. The problem is that they concentrate on documentary control and procedures that include details recorded on a compliance basis.

- *Environmental Management Model in Mexico:* the Environmental Management model thatis inferred from the documentary research, by the legislation that governs the mining-metallurgical industry in Mexico, is shown in figure 4:

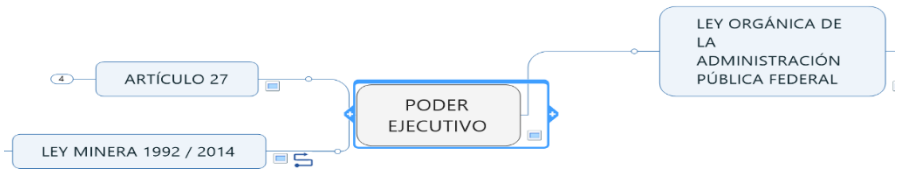
Figure 4. Legislation and Regulations regarding the Environment. Mexico.



Source: Own Elaboration.

For its part, the in-depth analysis of the various agencies and official documents that are involved in environmental matters, regarding Mining, is summarized as follows (figure 5):

Figure 5. Legislation in relation to Mining, Summary scheme. Mexico.



Source: Own Elaboration.

Article 27 of the Political Constitution of the United Mexican States, states that the Nation owns the territorial properties, as well as the use of natural elements to

equitably distribute public wealth, take care of conservation, achieve balance and the improvement of the living conditions of the country; In addition, to have the domain of that extracted from the mantles, deposits and veins of nature, being proper to allow or not, the exploitation of these (Mexican Political Constitution, 2019).

For its part, the Mining Law, the responsibility of the Executive of the Nation, carries out its application through the Ministry of Economy, which establishes the official procedure for the exploration, exploitation and benefit of minerals, including these from minerals base, those for industrial use, precious stones and rock derivatives, achieving their function by relying on the Mexican Geological Service (Ley Minera, 2014).

Regarding the Organic Law of the Federal Public Administration, in which 18 Secretariats are concentrated through which the Executive of the Nation operates according to the Political Constitution, and that of them, nine are involved in the exercise of the Mining, the foundations are established to acquire, manage territorial properties, permits or concessions of mineral domains, special expeditions such as transportation of minerals and raw materials for exploration, exploitation and benefit; ecological and environmental preservation, protection of human, financial, material and natural resources, growth of society through the quality of life of the communities and the means to publicize all related procedures and their updates as reforms.

Referential conclusion

Once the frame of reference was segmented and directed towards various models and programs that have been implemented in Mexico, but that coincide in their origin, that regardless of the place, is not part of the deeply rooted culture of the Mexican.

Making this count of the main models implemented, we value the success they have had not only in their implementation, but in their continuity, which is important to highlight, when it comes to programs or activities of which the Mexican worker was not expressly convinced, these tend to disappear, they can remain some time, even be present for decades as the ISO Standards , but the reality is that they are spontaneous acts of compliance, as they have slowed down the process due to their format of establishing documents for everything and for everyone. In this field, the Mexican worker reacts, is passive-active, but not pro-active.

The work environment with scenarios of freedom and real conviction, is one where creativity, loyalty and knowledge will be deployed by the Mexican employee in function of productivity (Martínez, 1998). Scenarios where roles are fully recognized and do not want to instill fear or punishment to get effective responses from your employees.

Chapter III describes the originality of this research based on the information that proposes Mexico as a significantly productive country in mining and specifically how San Luis Potosí contributes to these economic factors. The information of this frame of reference, also supports this condition of original, because it has been described how models of foreign origin are not fully accepted and well carried out in practice over time, which is often very short.

Thus, the model proposed in this research work is well-founded given the scenario where idiosyncracy is a key factor in the validity of the programs and, being a model with its own foundations, knowing the mentality of the Mexican worker, its acceptance can foramlizar a channel of effective action in favor of the environment.

4 Legal Framework

4.1 Mining Legislation in Mexico.

The mining-metallurgical industry is considered by the Federal Government of Mexico as an economic activity that promotes economic and social development, encouraging the use of mining resources and promoting investment; it is also committed to Social Responsibility programs (Undersecretary of Mining, 2017). Mining activity in Mexico is regulated in accordance with Article 27 of the Political Constitution of the United Mexican States and the regulatory Mining Law, documents that establish the rights and obligations assumed by the company when obtaining a mining concession (INEGI, 2011).The Mining Law, in terms of application to the Federal Executive through the Ministry of Economy, was presented in 1992 as a result of important reforms; The last reform published in the Official Gazette of the Federation was in August 2014 (Mining Law, 2014). The Ministry of Economy, declares in its mission, the promotion of the Mexican economy through the promotion of social and private companies in terms of regulation, market competition, diversification, improvement of the business environment, strengthening of the internal market and attraction of investment both national and foreign (Ministry of

Economy, 2017), in this way, the mining-metallurgical sector, according to the organic structure, is endorsed by this Ministry through the Undersecretariat of Mining and, in addition to this,

The Ministry of Economy, a dependency of the Federal Executive Power, within the Organic Law of the Federal Public Administration (DOF, 2018), occupies Article 34, which in mining matters, presents clauses XXVII, XXVIII and XXIX, which describe the functions of formulating and conducting the national mining policy, promoting the use of mineral resources, regulation of exploitation in nationally owned lands, as well as the granting of concessions, assignments, permits, authorizations in terms of the corresponding legislation.

The Undersecretary of Mining is a governmental body in charge of supervising and coordinating activities, preparing, formulating and evaluating plans and programs according to the Mexican Mining Law to ensure compliance with public policies. It was created in 2016 as a successor to the General Mining Coordination, which had been operating since 1995 (Organic Law of Public Administration, 2018).

The General Directorate of Mining Development, as part of its mission, promotes competitiveness and investment in the mining sector, seeking the application of public policies and the identification of business opportunities, as well as facilitating investments. This body generates the procedures, identifies Federal Dependencies and Sector Entities, integrates, classifies and translates the information in an indicative document called the Mining Procedures Guide, which contains basic and updated information on requirements, procedures, agencies and institutions involved. in the mining activity, as well as the costs that are managed before the Government Instances (General Mining Coordination, 2014).

For its part, the General Directorate of Mines guarantees legal security to the national mining activity, verifies the transparent and timely application of current regulations. One of the most important functions of this body is the issuance of mining concession or assignment titles, from which others are derived, such as keeping the public mining registry updated, participating in the development of official standards regarding safety, health and environment. environment. In general terms, it manages the mining concessions whose titles are granted by the Federal Executive through the Ministry of Economy (General Mining Coordination, 2014).

These three organizations, derived from the Ministry of Economy of the country, are responsible and described in the official organization chart, however, they are in turn conformed by others that carry out specific and delimited functions in search of agility, effectiveness and efficiency in the activities that concern mining matters of the nation.

To support the activity of the mining sector, nine federal agencies are involved, the functions they perform, involve specific areas or topics according to the mission that each agency emanates (General Coordination of Mining, 2014):

1. Ministry of Finance and Public Credit -SHCP.
2. Ministry of the Environment and Natural Resources -SEMARNAT
3. Ministry of Agrarian, Territorial and Urban Development -SEDATU.
4. National Commission for the Development of Indigenous Peoples -CDI.
5. National Water Commission - CONAGUA.
6. Mexican Institute of Social Security –IMSS.
7. Ministry of Labor and Social Welfare - STPS.
8. Secretariat of National Defense - SEDENA.
9. Ministry of Energy –SENER.

SEMARNAT stands out for the purposes of this subject, which evaluates in terms of environmental impact and land use, the exploration, exploitation and benefit of minerals, based on the Mining Law (General Mining Coordination, 2014).

4.2 SEMARNAT and the Mining-metallurgical Sector.

Ministry of the Environment and Natural Resources (SEMARNAT), created in 2000, is in charge of incorporate in the different areas of society and the public function, criteria and instruments that ensure the optimal protection, conservation and use of the country's natural resources, thus shaping a comprehensive and inclusive environmental policy that allows achieving Sustainable Development (SEMARNAT, 2014).

SEMARNAT has three undersecretaries:

1. Undersecretariat of Environmental Promotion and Regulations
2. Undersecretariat of Management for Environmental Protection
3. Undersecretariat of Planning and Environmental Policy

These Undersecretariats, together with various Decentralized and Decentralized Bodies, work to benefit the conservation and sustainable use of ecosystems and their

biodiversity, the prevention and control of pollution, the comprehensive management of water resources and the fight against climate change. as priority points (SEMARNAT, 2014).

In reference to the mining sector, the Undersecretariat for Environmental Promotion and Regulation is in charge of promoting optimal environmental performance regarding the impacts that may be generated (SEMARNAT, 2014). The environmental obligations that mining-metallurgical companies must comply with are subject to authorizations or permits granted by the dependencies of the Public Administration, depending on the activities that they intend to carry out. For this, Official Mexican Standards (NOM) were created, applicable to the mining sector on environmental issues, in addition to addressing the impact of the sector on other Standards that verify other issues: water, residual discharges and atmospheric emissions, waste.

The Undersecretariat presents a series of descriptions contemplating environmental impacts (SEMARNAT, 2014), which are presented in a document called Environmental Impact Assessment, which establishes the conditions to which the performance of works and activities that may cause ecological or ecological imbalance will be subject. Exceeding established limits and conditions applicable to protection of the environment and preservation and restoration of ecosystems, describing for this purpose, the stages of the mining-metallurgical process: Prospecting, Exploration, Exploitation and Benefit of minerals and, Closure and Remediation.

- **Prospecting,** origin stage of the mining process, describes characteristics that define potential areas that contain minerals; Through geological studies, the appropriate information is presented to request authorizations from SEMARNAT. The studies are of gravimetric, surface geological, magnetotelluric prospecting, which indicates that they are indirect, non-invasive methods, so they are not subject to environmental impact assessment.

- **Exploration:** At this stage the areas of interest are recognized, in order to confirm the physical and chemical characteristics that show that there are mineral deposits; the shape and dimension of the deposit is defined by geological methods of direct sampling. Prior to these studies, authorizations are required,

which already involve data on environmental impact, land use, works or activities in protected natural areas.

To prevent environmental impacts, in works and mineral and substance exploration activities, a Preventive Report (IP) or an Environmental Impact Statement (EIM [3]), which SEMARNAT defines if the IP adheres to the specifications of NOM-120-SEMARNAT-2011[4], or it is necessary to present the MIA.

The environmental impacts that could be generated in the Protected Natural Area, require MIA. Likewise, when a change in land use is proposed, that is, there could be partial or total removal of vegetation, verification of soil type: forest, forest, jungle, arid zone, among others. For this, in addition to presenting the MIA, a Justifying Technical Study is required to show that biodiversity is not compromised, there will be no soil erosion, deterioration or water decrease, long-term soil characteristics, among other impacts.

The closure of this stage is expressed with the mining concession title, which also contains an information document indicating the location of the mining lot, which was studied to take care of protected natural areas.

- **Exploitation and Benefit of Minerals:**Based on the results obtained in the Exploration, feasibility studies and economic evaluation are prepared in order to exploit mineral reserves, select mining method, calculate mineable volumes, extraction cost, alternatives and cost of the process and subsequent commercialization; Likewise, studies of estimating the cost of environmental remediation are presented. Exploitation are works aimed at preparing and developing the area where there are mineral deposits, as well as activities aimed at extracting said minerals or substances from nature; For its part, the benefit is the work of preparation and treatment, smelting and refining of the extracted

[3] EIM: Document that, based on studies, expresses the significant and potential environmental impact, as well as the way to avoid it, lessen it or mitigate it, that a mining work or activity can generate.

[4] NOM-120-SEMARNAT-2011, establishes specifications for this stage of direct mining exploration in agricultural, livestock or wasteland areas and in areas with dry and temperate climates, where xerophilous scrub vegetation, tropical deciduous forests, coniferous forests or oaks develop .

mineral products, with the purpose of recovering minerals and substances in terms of purity (separation).

If the reserves indicate that the project is favorable, SEMARNAT issues permits and authorizations in matters such as: environmental impact, change of land use in forest land, works or activities in protected natural areas, waste and emissions to the atmosphere and water.

The environmental impacts to be prevented involve support infrastructure, final disposal of waste in tailings dams, for which an EIS must be submitted. If they are also considered highly risky activities [5], the MIA must include an Environmental Risk Study (ERA). Once the ERA is evaluated, an Accident Prevention Program must be presented, where preventive action measures against analyzed risks will be described.

If the activities or works include Gold, Silver or Copper leaching systems (chemical separation to recover pure mineral), as well as tailings dams, such works must also adhere to the provisions set forth in the corresponding NOM:

NOM-155-SEMARNAT-2007 (environmental protection requirements for Gold and Silver leaching systems),

NOM-159-SEMARNAT-2011 (environmental protection requirements for Copper leaching systems) and,

NOM-141-SEMARNAT-2003 (procedure to characterize tailings, site preparation, operation and post-operation of tailings dams).

Regarding mining waste, they will adhere to the General Law for the Prevention and Comprehensive Management of Mining-metallurgical, hazardous, special management and urban solid waste (LGPGIR). Mining waste is regulated and falls under federal jurisdiction through NOM-157-SEMARNAT-2009, which also determines whether or not it is dangerous.

Emissions to the atmosphere are regulated in the first instance by the Single Environmental License (LAU), which grants authorizations in the prevention and control of atmospheric pollution for the operation of industrial establishments, such as the metallurgical industry. An Annual Operation Certificate (COA) must

[5] Highly risky activities: Handling of toxic substances, handling of flammable and explosive substances.

be created, an instrument for monitoring industrial regulation, which reports emissions and transfers of pollutants and substances into the air, in wastewater discharges, soil, and hazardous waste.

The water used in different processes of the mining-metallurgical activity must have concessions and permits in charge of the National Water Commission (CONAGUA), following the NOM-001-SEMARNAT-1996, which establishes maximum permissible limits of contaminants in wastewater discharges.

- **Closure and Remediation**: Once the mining-metallurgical operation ends, the closure must be strategically planned, with the vision of reintegrating the used property to its natural or urban environment. At the beginning and during the operation of the mining-metallurgical activities, actions are carried out to correct the ecological impact. Before closure, remediation works are carried out, equipment is removed at the end of operations, while post-closure is monitored and environmental maintenance is provided.

The environmental impact generated by these closing stages must be declared in the MIA, likewise, it must adhere to NOM-141-SEMARNAT-2003, NOM-155-SEMARNAT-2007 and NOM-159-SEMARNAT-2011.

The remediation involves a program which is evaluated by SEMARNAT; It derives from a contaminated site, calling it an environmental emergency or when there is an environmental liability. These are measures to eliminate or reduce contaminants to a safe level for health and the environment, provided for in NOM-133-SEMARNAT-2000 (management specifications for environmental protection-polychlorinated biphenyls), NOM-138-SEMARNAT / SSA1 -2012 (maximum permissible limits of hydrocarbons in soil, specifications for remediation) and, NOM-147-SEMARNAT / SSA1-2004 (criteria for soil remediation for arsenic, vario, beryllium, cadmium, chromium, mercury, nickel, silver, lead , selenium, thallium and / or vanadium).

4.2.2 Environmental Management in Mexico.

Regarding the development of Environmental Management in Mexico, the research carried out by Pérez (2010) is considered: the environmental policy of 1841, is considered the beginning, when the Superior Council of Health of the Department of Mexico is created, in addition to a sanitary code; around 1917, the Public Security

Secretariat was created and in 1943 the Security and Assistance Secretariat, which would be responsible for Environmental Management.

In 1971 the Federal Law to Prevent and Control Environmental Pollution was created, being the first Mexican legal system with provisions on air, water and soil; In 1972, as a dependency of the Ministry of Health and Assistance, the Undersecretariat for Environmental Improvement was created.

Environmental policy acquires a comprehensive approach: in 1982 the Federal Law for Environmental Protection was created, in 1983 the Ministry of Urban Development and Ecology was created, which among its scope, considered the preservation of resources counteracting the effects of industrial concentrations, which created a structure that had an Undersecretariat and four Directorates in 1985. These efforts are strengthened with the creation of the National Ecology Commission, which also includes the Undersecretariat of Ecology and the National Ecology Program.

Around 1988, the General Law of Ecological Balance and Environmental Protection was born, considered as the basis of the country's environmental policy. In 1989, the National Water Commission was born, in 1992 the Secretariat for Urban Development and Ecology became the Secretariat for Social Development (SEDESOL), the National Institute of Ecology (INE) was also created, the latter being focused on information scientific about environmental problems; The Federal Attorney for Environmental Protection (PROFEPA) is also created, which is responsible for the enforcement of environmental justice.

Starting in the 1990s, the approach to environmental policy has shifted towards Sustainable Development, in which an integration of economic, social and environmental objectives takes place. In 1995, the Secretariat for the Environment, Natural Resources and Fisheries and the Environment Program were created. At the beginning of the year 2000, the Federal Public Administration Law changed and gave rise to the Ministry of the Environment and Natural Resources (SEMARNAT) and the National Environment and Natural Resources Program, which adopted an institutional design and structure in the that environmental policy is established as State Policy.

SEMARNAT and its three sub-secretariats: Environmental Planning and Policy, Management for Environmental Protection, and Environmental Promotion and

Regulation, also have six decentralized bodies: federal delegations, regional coordinators, National Water Commission (CNA), Institute of Ecology (INE) , The Federal Attorney for Environmental Protection (PROFEPA) and the National Commission for Protected Natural Areas (CONANP) and two decentralized bodies: the Mexican Institute of Water Technology (IMTA) and the National Forestry Commission (CONAFOR). SEMARNAT, within the Environment Sector Program 2007-2012, was in charge of the management. Simultaneously, federal laws were created: in 2003 the Sustainable Forestry Development Law, in 2004 the National Waters Law, in 2005 the General Wildlife Law and the Biosafety Law.

This Administration is structured in environmental matters in a broad way, contemplates Organic Statutes such as that of the National Institute of Ecology and Climate Change, created in 2013. As of 2000, various regulations are created and updated that regulate the environment, natural resources, balance ecological based on external impacts due to industrial or service activity.

The Federation is based on Civil Codes, updated between 2012 and 2013. The Laws that regulate, already contemplate Sustainability and are marked in the National Development Plan 2013-2018.

4.2.3 Economic Development Strategy coupled with environmental matters

At the end of 1980, a change was generated in the economic development strategy, since it was oriented towards strengthening market mechanisms as resource allocators, generating measures such as economic deregulation that eliminates excessive federal regulations and reduces obstacles to receiving foreign investment. . Thus, mining lays the foundations for reforming the mining system, being published in the Official Gazette of the Federation in June 1992, with the adoption of the current Mining Law (Isla, 2002).

In environmental matters, this Law contemplates within its Obligations, the approval of the Environmental Impact Statement for exploitation works, and some exploration works. These Manifests of Environmental Impact (MIA), generate a document based on a technical study carried out of works or planned activities, where they analyze and describe the environmental conditions prior to the completion of the project, generally covering the four seasons of the year, in order to evaluate potential impacts

on flora, fauna and the environment that could be caused by the construction and operation of works or the performance of activities, as well as the definition and proposal of the necessary measures to prevent, mitigate or compensate for said alterations (SEMARNAT, 2013).

The objective of the evaluation that is required to carry out an environmental impact manifesto is Sustainability, coupled with the feasibility and social benefit and the use of natural resources.

The National Development Plan 2007-2012, assumed the principles of Sustainable Human Development as a guiding principle and Environmental Sustainability as one of the five axes of Public Policy, emphasizing the efficient and rational administration of natural resources, of so that there is an improvement in social welfare without compromising the quality of life of future generations (SEMARNAT, 2010).

4.2.4 Socially and Environmentally Responsible Company

Morales and Estrada (2006), express about Corporate Social and Environmental Responsibility being proactive, proactive and committed. It develops business initiatives that go beyond compliance with laws, regulations and compliance with profitability objectives. A socially and environmentally responsible company seeks the well-being of workers, respect for the environment, reduction of impacts; in general, it cares about the common good, allowing continuous improvement of environmental performance. It also considers sustainable, social, economic, technological and environmental dimensions, its foundation being Sustainable Development expressed in economic growth and the preservation of the environment.

Social Responsibility has developed different theoretical proposals, seeking to define the reason for being and the elements to consider, so that when applied, the concept integrates social and environmental aspects in its operations and interaction with stakeholders (Dahlsrud, 2006, cited in García, Portales, Camacho, Arandia, 2010)

Efforts to carry out the Sustainability plan within the mining industry have expanded based on balances between the impacts generated by the exploitation and extraction of resources and the arduous way in which it seeks to form new natural areas and social and economic well-being. In this way, the mining industry provides alternative

solutions not only in economic management, but also provides environmental and social elements to distribute profits and have the financial capacity to invest in programs that promote and build well-being for all.

This becomes Social Responsibility programs, whose achievements are very visible in the communities surrounding the mining estates, since they become the lifting of infrastructure such as schools, secondary schools and hospitals; efficient and effective communication routes, sports and recreation areas.

By harmoniously combining the three bases of Sustainable Development (economic, environmental and social), it can be described that the mining industry seeks, based on the law by which it is governed, to generate stability and commitment in our country, promoting its culture of Responsibility Social, based on Sustainability.

Reflection

In Mexico, the mining industry has been involved in environmental problems, derived from the lack of regulation and legislation over time, it is considered that there are sites contaminated with organic and inorganic compounds derived from this industry in addition to petrochemicals. Likewise, the use of remediation technology is contemplated, these being biological methods, among which are more frequently composting, bio-tillage, soil washing, chemical oxidation and physical separation, however there is no technology offered for remediation of soils contaminated by metals (Volke, Velasco, 2002).

The environmental damage that mining-metallurgical activities can cause is reflected in contamination of water, soil, air, deterioration of resources and ecosystems (ODG, 2002), since volumes of solid, liquid and non-gas was released into the environment. treated and not considered within the environmental cost of production.

The environmental impacts that occur as a consequence of the activities in this sector vary according to the type of mineral and mine, since by its nature it implies exploitation of non-renewable resources through procedures such as crushing, grinding, washing, leachate and mineral classification. , refining and smelting (IIED / WBCSD, 2002). These impacts have been classified by Young (cited in González, 2006), as general impacts to the environment, referring to the habitat, pollution

impacts declared in the soil (residues); impacts of water pollution and impacts of air pollution (emissions).

One of the most notorious impacts is that of the generation of waste, since it is necessary to create patios, recognized as tailings, gravel and slag dams; These tend to concentrate heavy metals such as cadmium, chromium, copper, lead, zinc, and metalloids such as arsenic. It is estimated that in mining farms greater than 100 km2, 50,000,000 m3 of waste can be generated, necessarily promoting environmental regulations for disposal and management as hazardous waste (UNEP, 2000).

The possibility of establishing adequate strategies to promote the conservation of the environment may exist if the mining-metallurgical sector has evidence of how its environmental practices promote the mitigation of impacts and thereby achieve balance and compliance with regulations, standards and laws, in addition to contribute with international values that activist organizations seek to standardize in all industrial sectors to conserve and recover human well-being through the care and use of the environment and natural resources.

Caring for the environment, is generally understood in the toindustrial field, as part of the functionorn organizational, social and, more than anything, it is aimed at basic programs of "retribution" to the environment. Therefore, this research encourages the linking of universal and national programs,which allow cross-sectional analysis of the practices that are carried out in relation to the environment, which is presumed to be impacted when the mining-metallurgical sector carries out its own extraction and extraction of minerals according to the needs of society.

CHAPTER III. ORIGINALITY RESEARCH: SAN LUIS POTOSI´S MINING INDUSTRY ANNOTATIONS

PRESENTATION

It presents the information that supports the operability and economic importance of the metallurgical mining industry in Mexico and highlighting for its contribution, the state of San Luis Potosí, its characteristics and the mineral benefits that propose it as a significant state that has mining-metallic representation.

The chapter is divided into two sections: the first section corresponds to general industrial mining-metallurgical data, in which Mexico is located as a globally recognized mining producer, where statistically speaking, it provides information relevant to internal economic indicators and which in turn promote the nation as a good destination for investments by exploration and mining operation in several of the minerals of which deposits are abundant and their "value of law" it's high quality.

The second section corresponds to the presentation of the state of San Luis Potosí, selected as the object of study of this research project. Relevant information is shown that allows the reader to understand why it is a significant state and how by its economic indicators, it is proper to select the mining-metallic sector, which also has historical importance when belonging in time from the colony to the center of the "*Camino de Tierra Adentro"*, or "*Camino de la Plata"*, and which is due to its metal production and geographical location, being towards the center of the country.

This chapter shows how the state of San Luis Potosí, in reference with the Metallic Mining Industry, based on general data and indicators that influence the economy of Mexico. Emphasis is placed on the metal sector, which is representative and significant for some important metals and which also stand out for its global importance, such as silver among many others.

At the end of the chapter, the *originality* of this research its justified, based on described information that lies in the importance of the metal mining sector in Mexico, which represents 16% of the economic participation, occupying the 6th place as an industrial sector (INEGI, 2017), and the possibility of extending to the entire mining-metallurgical industrial sector of Mexico, a Sustainable Management Model, which is based on the international suggestions of the UN (2015) with the 2030 Agenda, allowing to be part of a strategy that evaluates alignment with sustainable principles

without neglecting the legislative obligation that is being had, so the connection between the topics, promotes this thesis as relevant and that generates new lines of research to implement the Model in other units of the metal mining sector in the state of San Luis Potosí, other states and gradually within the mining-non-metallic and metallurgical sector.

1. Description of the Mining-metallic sector

Starting with the mineral deposits, that consist of minerals surrounded by useless material, these are classified as metals and non-metals, in which metal is called the element that possesses characteristics like maleability, ductility, metallic luster, heat and electricity conductibility; chemically it carries out the positive or basic part of a simple compound (SEMARNAT, 2017).

The metallic minerals are frequently found chemically bound to other metals, forming the veins, which then appear also with non-metallic minerals, rocky not usable or sterile material. They are generally found in the depth; however vast deposits exist close to the surface (SEMARNAT, 2017).

> Metals are classified as ferrous (iron, manganese, chromium, molybdenum, nickel, cobalt, tungsten and vanadium) and non ferrous, which then are subdivided in basic (copper, lead, zinc and tin), light (aluminium, magnesium, titanium), precious (gold, silver, platinum) and radioactive (uranium, thorium).

Non metallic elements are those that do not possess the physical properties like ductility, malleability and conductance; their composites perform the negative or acid role. Nonmetalliferous deposits may appear as monomineral deposits (SEMARNAT, 2017).

> Combustibles (petroleum [oil], natural gas, mineral carbon), construction materials (sand, gravel, limestone), chemical substances (salt, sulphur), fertilizers (fosfates, potash and nitrates), ceramicals (clay, silica, feldspars), abrasives (industrial diamond, corundum, emery, sands), insulators (magnesites, asbestus, mica), and paints (ocher, clay, diatomite and baryta); metalurgical and refractories (fluorite, cryolite, graphite, sands and limestone), industrial and factory materials (asbestus, mica, talcum, baryta, sands, clay and optical crystals), precious stones.

The superficial part of the deposit is extracted with open pit excavations; when the deposit is deep and its extraction is economically feasible, the operations are performed underground (SEMARNAT, 2017)

The mining units are part of various chains of industrial production, as they contribute metallic and non metallic minerals in their natural state and concentrated; other concerns consume these minerals and perform the melting or refining of the metals, generating laminated products, rough dressings and other basic metal products. Later these products are transformed in various ferrous and non ferrous items (INEGI, 2011).

The mining industry develops into an integrated activity, recognised as *Mining-metallurgical Industry*, as the mineral resources required an industrial transformation for their utilisation (Martínez and Rivera, 2018).

1.1 Mining Process as Related to the Environment.

The "Secretaría del Medio Ambiente y Recursos Naturales" -SEMARNAT- (Ministry of the Environment and Natural Resources) evaluates on the subject of environmental impact and soil use, the activities of exploitation and ore improvement, on the basis of the Mining Law (Coordinación General de Mina, 2014). Its task is to incorporate in the various segments of society and the public function, criteria and instruments that insure the optimal protection, conservation and profit from the natural resources of the country, shaping in this manner an integral and inclusive environmental policy that promotes the goal of reaching a sustainable development (SEMARNAT, 2014)

Environmental impacts are defined as "changes caused by the intervention of humans in nature, that can cause ecological lack of equilibrium". Once known they must be declared in order to get the required approvals from the regulating organs to develop a mining-metallurgical project (SEMARNAT, 2014).

The stages of the mining-metallic process, contemplated for its difusion and enviromental control are the following, relating to the environmental impacts (SEMARNAT, 2014):

Prospecting. Initial stage of the mining process; the; characteritics which define potential areas that contain minerals are therein described; through geological studies the appropriate information for requesting authorisations to SEMARNAT is presented. The studies are of gravimetric prospection, superficial geology, magneto-teluric, which shows they are indirect not invasive methods, so they are not subject to the evaluation of the environmental impact.

Exploration. In this stage the areas of interest are defined, with the end of confirming the chemical and physical characteristics that prove the existence of mineral deposits; the form and extension of the deposit are defined using geological methods of direct sampling. Before these studies, authorisations are required, which already involve environmental impact data, use of the soil, works or activities in natural protected areas.

To forewarn of environmental impacts, in works and activities of exploration of mineral and substances, an Informe Preventivo (IP) -*"Peventive Inform"* or *Environmental Impact Manifest* EIM[6]; SEMARNAT defines if the IP conforms to the specifications of the NOM-120-SEMARNAT-2011[7] or it is necessary to present the EIM.

The environmental impacts that could be generated in Protected Natural Area demand an EIM. In the same manner, when a change in use of soil is proposed, that is, that there could be partial or total removal of vegetation, confirmation, corroboration of the type of soil; forest, woods, jungle, and arid zone among others. In this case, in addition topresenting the EIM, a *Justification Technical Study* is required, in which it is proved that the biodiversity has not been compromised in the long run, including that soil erosion, detriment or reduction of water, and characteristics of the soil in the long run have been considered.

The conclusion of this stage is reached when the "*título de concesión minera*[8] "

[6] EIM: Environmental Impact Manifest, document that based on studies expresses the significant and potencial environmental impact that a mining activity can generate, as well as the way to prevent it, reduce or soften it.

[7] NOM-120-SEMARNAT-2011, establishes specifications for this stage of direct mining exploration in agricultural, livestock or wood areas and in areas with dry and temperate climates, where xerophilic scrub vegetation, deciduous tropical forests, coniferous or oak forests are developed.

[4] Title of mining concession. Document that testifies the declaration of a mining deposit, which provides the rights to explore and/or exploit the existing minerals therein.

(title of mining concession), which additionally includes an informative letter that contains the location of the mining lot which was studied to take care of protected natural areas.

Exploitation and Benefit of Minerals: on the basis of the results reached in the Exploration, feasibility studies and economical evaluation are prepared, with the purpose of exploiting mineral reserves, select type of mining, calculate ore volumes, costs of extraction, alternatives of the later comercialisation process and its costs, in the same manner, cost estimate studies of environs remedial are presented. Exploitation are works destined to prepare and develop the area where there are mineral deposits, as well as activities devoted to extract such minerals or substances from nature; on the other side, benefit are the works of preparation and processing, smelting and refining of the extracted ores, with the purpose of recovering minerals and substances according to their purity (separation).

If the reserves show that the project is worth while, SEMARNAT issues permits and authorisations in matters like: environmental impact, change of soil use when it is forest land, work and activities in protected areas, residues and emissions into water and air.

The environmental impacts to prevent encompass the support infrastructure, the final disposal of residues in leftover dams, for which an EIM needs to be submitted. If additionally they are considered *highly risky activities*[9], the EIM must include a Study of Environmental Risk ("Estudio de Riesgo Ambiental, ERA"). Once the ERA is evaluated a Programme of Accident Prevention must be submitted, where the preventive actions against the risks contemplated is described.

If the activities or construction include Gold, Silver or Copper lixiviation systems (chemical separation for recovering pure material) in addition to waste dams, such activities must follow dispositions prescribed in the corresponding NOM[10]s:

NOM-155-SEMARNAT-2007 (environment protection requirements for Gold

[9] Highly risky activities: Handling of toxic substances, handling of flammable and explosive substances.

[10] NOM: Norma Oficial Mexicana (Official Mexican Standard)

and Silver lixiviation systems),

NOM-159-SEMARNAT-2011 (environment protection requirements for Copper lixiviation systems), and

NOM-141-SEMARNAT-2003 (procedure for characterisation of waste deposits, site preparation, operation and post-operation of waste dams).

In relation to the mining residues, these shall conmply with the "Ley General para la Prevención y Gestión Integral de los Residuos Minero.Metalúrgicos" (General Law for the Prevention and Integral Administration of the Mining and Metalurgical Residues), which are dangerous, needing special handling and include urban solids. The mining residues are regulated and of federal concern, by the NOM-157-SEMARNAT-2009, which also determines if they are dangerous or not.

Emissions to the atmosphere are regulated firstly by the " Licencia Ambiental Única" (Unique Environment Licence), which provides authorisations for the operation of industrial concerns, as the metallurgic industry in relation to prevention and control of the atmospheric contamination. An Annual Operation Card needs to be created, as an instrument to watch industrial regulation, that will report emissions and transmissions of contaminants and other substances into the air, in discharges of residual water, soil and dangerous residues.

The water utilised in the several processes of the mining-metallurgical activities, must have concessions and permits issued by the "Comisión Nacional del Agua", (National Water Commission) adhering to the NOM-001-SEMARNAT-1996, where maximum permissible levels of contaminants are established for residual water discharges.

Closure and Remediation: Once the mining-metallurgical operations end, the closure needs to be strategically planned, with the view of restoring the used site to its natural or urban surroundings. In the beginning and during the operation of the mining-metallurgical activities, correction actions of ecological impact are performed. Before the closure restorative work is performed, equipment is retired, whilst after the closure environment monitoring and maintenance is supplied.

The environment impact that occurs during this closing stage needs to be declared

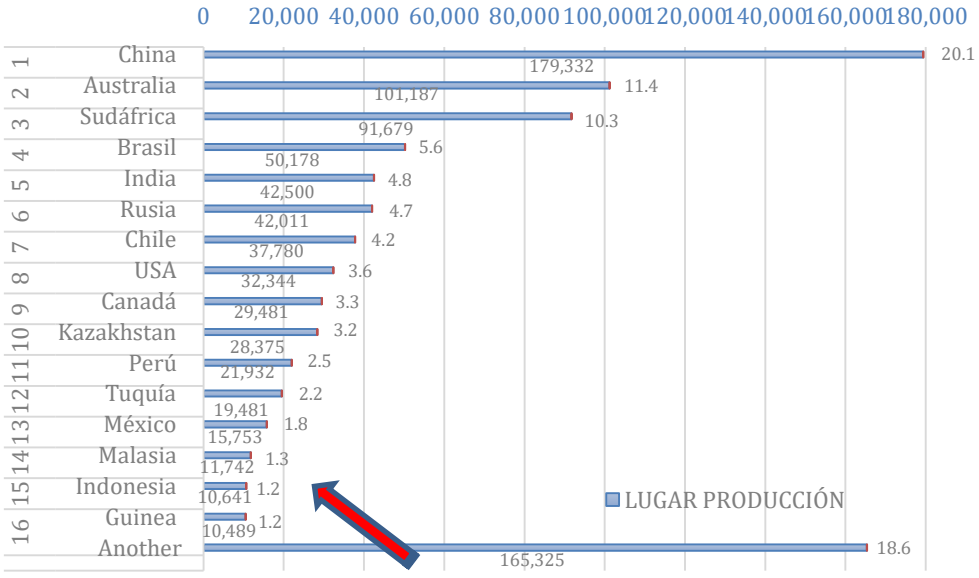
in the MIA, and comply with NOM-141-SEMARNAT-2003, NOM-155-SEMARNAT-2007 and NOM-159-SEMARNAT-2011.

Remedial work involves a programme that is evaluated by SEMARNAT; it proceeds from a contaminated site and is designated an environmental emergency when a passive habitat exists. It consists of measures for the elimination or reduction of contaminants down to a level that is safe for health and the environment, as stated in the NOM-133-SEMARNAT-2000 (specifications for the handling and environment protection- policloride biphenyles), NOM-138-SEMARNAT/SSA1-2012 (maximum hydrocarbons permissible in soil, specifications for remedial work), and NOM-147-SEMARNAT / SSA1-2004 (criteria for remediation of soil from arsenic, barium, berilium, cadmium, chromium, mercury, nickel, silver, lead, selenium, thalium and/or vanadium).

2. Contextualization: Mining Industry in Mexico

Mexico has an active participation worldwide within the Mining-Metallurgical Industry; Figure 6 presents data from Word Mining Data (2018), which shows that the country occupies the thirteenth place as a producer, with 1.8% contributing $15,753 million annually, thus promoting itself as a country suitable for investments in mining exploration.

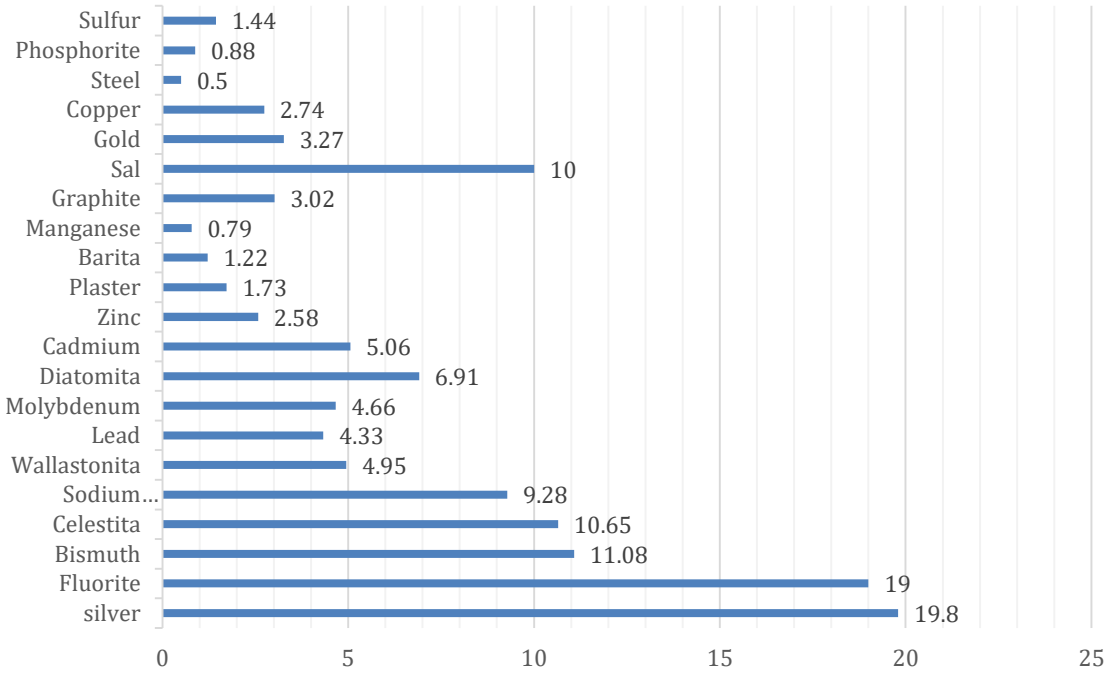
Figure 6. Participation of Mexico in global mining production (millions of dollars)



Source: Own elaboration based on World Mining Data, 2018.

The Mining-Metallurgical Industry has a strong economic contribution in Mexico and, geologically, geography stands out for its mineral richness. As shown in Figure (7), Mexico is among the top 10 producers in the world of 16 minerals (SGM, 2018), with Silver being one of the world's largest precious metals with a 19.80%. Inland, Silver contributes to economic indicators with 27% domestic production.

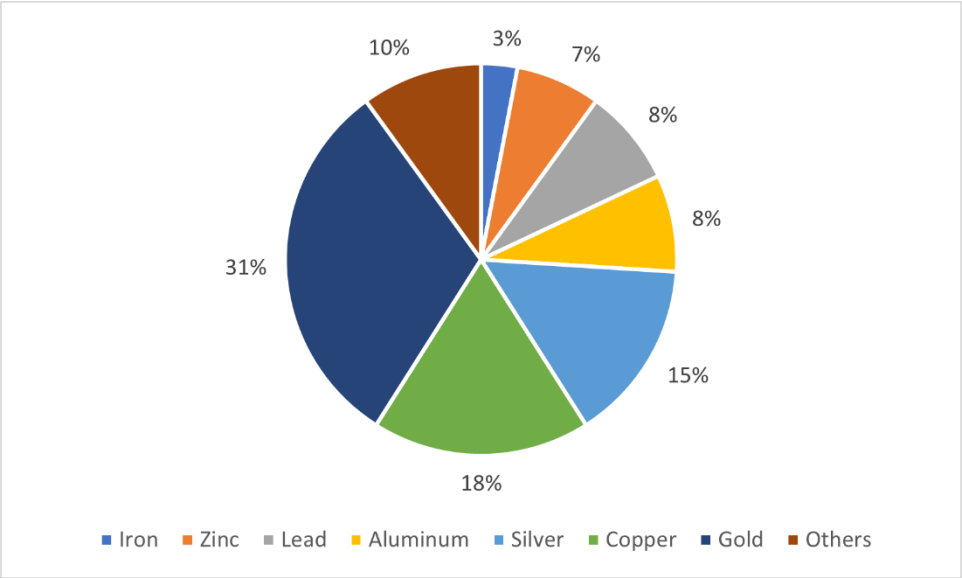
Figure 7. Mexican mining percentage of participation in world production



Fuente: Own preparation based on Servicio Geologico Mexicano, 2017

With regard to exports made by the mining industry, the effect of foreign exchange income on the country makes it fundamental. The mining metallic industry has strengthened the country's economy without being with drastic changes to the variations in international metal prices.

Figure 8. Metallic mining explorations



Source: Mexican Geological Survey, (SGM, 2018).

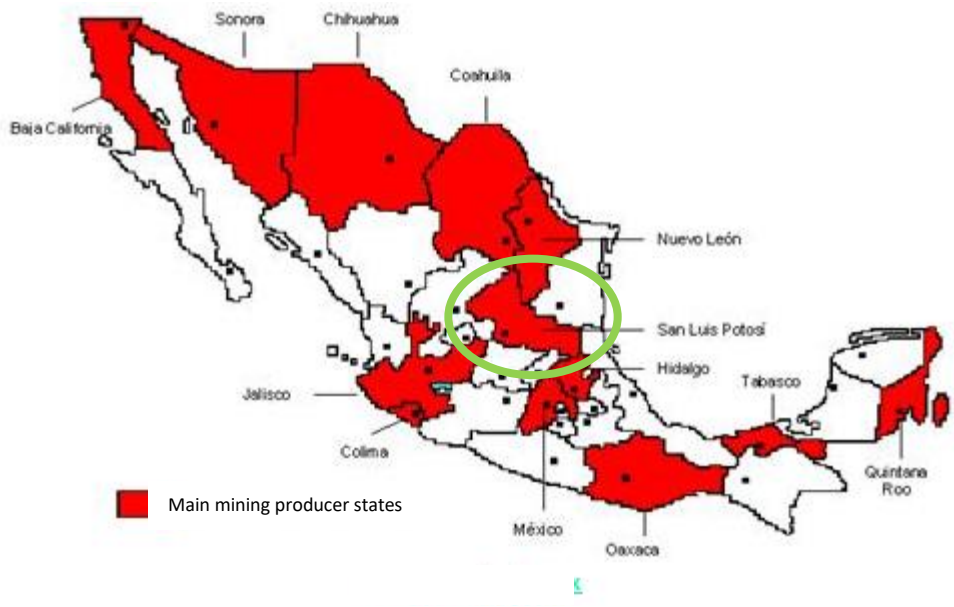
Mineral quotes fluctuate according to various factors worldwide, considering mainly two large groups:

Minerals considered strategic and speculation such as gold and silver whose down-and-down market price is due to the security it provides for the holder of economic stability and should only be aware of high productions and recoveries of metals based on recycling, but generally represents a guarantee for investors to retain their value. The group of industrial minerals, whose contribution is fluctuating by the effect of industry and its needs on the industrial and development world of nations.

Within the Mexican Republic, the state of San Luis Potosí stands out for its mining-metallurgical production, with underground mines, open pit mines, concentrator plants and refineries, all divided into metallic minerals as non-metallic and, represented by important foreign and national corporations.

It also represents an ideal climate for the realization of business and productive investment, consolidating it as a politically stable state, social cordiality and high levels of personal and heritage security, factors that allow the development of human, physical and labor capital (BANCOMEXT, 2018).

Figure 9. Main mining producer states of Mexican Republic



Source: School of Mines of Zacatecas, 2018.

3 San Luis Potosi, financially outstanding state in Mexico

The history of mining in Mexico dates back to before the spaniard conquest and in the state of San Luis Potosí since 1574 in the mineral of Charcas, located north of the capital of the entity; in 1592 the mineral of San Pedro was discovered, which gave origin to the city of San Luis Potosí for its proximity and its richness in silver. The state was part of the "Silver Route" at the time of the conquest, becoming, along with other surrounding states such as Zacatecas, Guanajuato, Querétaro, among others, mining icons in the country.

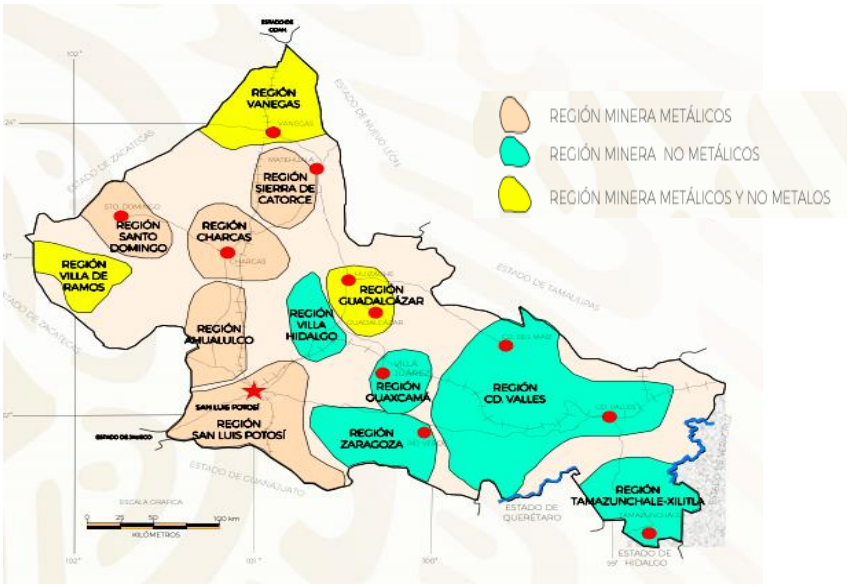
The entity is located in the eastern central part of the Mexican Republic, between the parallels 21º-09' 35" and 24º-33'09" north latitude and the meridians 98º-19'35" and 102º-17'51" of Longitude to the west of Greenwich, bordering to the north with the states of Coahuila, Nuevo León, Tamaulipas and Zacatecas; to the East with Veracruz, to the south with Hidalgo, Querétaro and Guanajuato and to the west with Jalisco and Aguascalientes. Some of the general geographic data of the state of San Luis Potosi, that are important to the commercial and industrial flow for the country are:

- 62,304.74 Km^2 of surface.
- Railways: 1,279 Km.
- Population: 2,717,280
- Roads: 12,545 km

The state of San Luis Potosi represents 3.12% of the Mexican territory and in turn, has 91% mineralized soil (SGM, 2018). Mineralization and geographic location promotes it as an economically active state by attracting 5.9% of foreign investment in mining. The state ranks 1st in the country in the production of Fluorite (and second in the world), 3rd place in Zinc and Copper production, 5th in Gold and 8th in Silver, data that place it as the 5th state in Mexico in its mining production (BANCOMEXT, 2018).

Figure (8) shows the location and distribution of metal, non-metallic and containing mining deposits, through the state of San Luis Potosí, so basically 50% of the state is traversed by the Au-Ag-Pb-Cu-Zn mineralization trend.

Figure 10. Distribution of mining-metallurgical deposits in San Luis Potosí



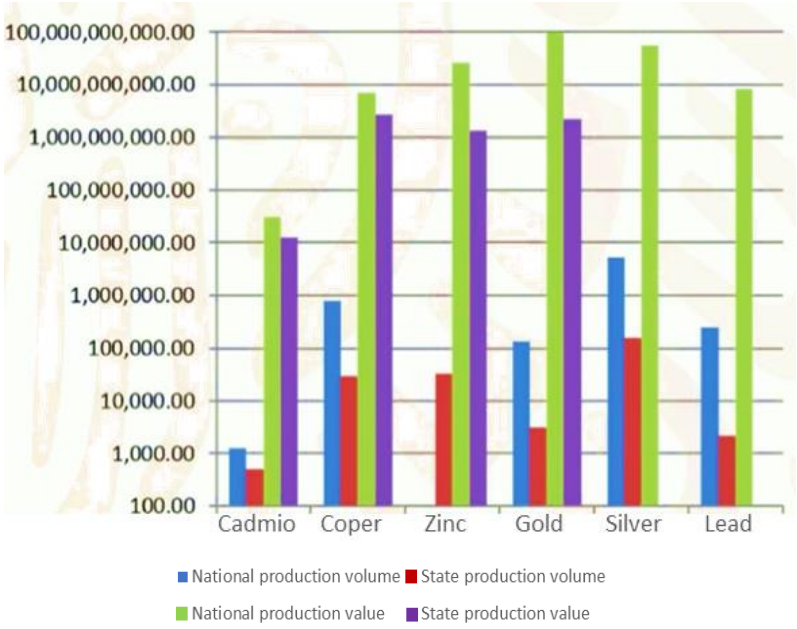
Source: Mexican Geological Survey (SGM, 2018).

The distribution of active mines in the state is variable in terms of elements, highlights the Silver in metallic minerals, accompanied by minerals of Lead and Zinc. At non-metallic minerals protrudes the Fluorite with the largest deposit in the world with underground mining.

Also the production and participation in domestic production is noted the contribution of the state of metallic minerals, and how its value generated by this production, mostly by the effect of the production of Gold and Silver. The share of volume and value in domestic production of metallic minerals is distributed as follows (SGM, 2019):

Table 3: Participation of Metallic minerals of San Luis Potosi in national production's volume and value

Products	National production volume	State production volume	National production value	State production value	Percentage
Cadmium	1,307.00	536.32	67,290,325.18	27,612,284.29	41.03
Coper	696,580.11	4,588.89	87,683,314,443.74	577,635,424.24	0.65
Zinc	662,354.92	31,134.97	37,830,212,497.27	1,778,265,099.44	4.70
Gold	141,143.38	---	110,849,270,444.21	---	0.00
Silver	7,243,245.11	68,938.00	70,412,848,613.71	670,158,317.72	0.95
Lead	230,869.36	1,979.52	9,981,816,425.17	85,586,216.28	0.85

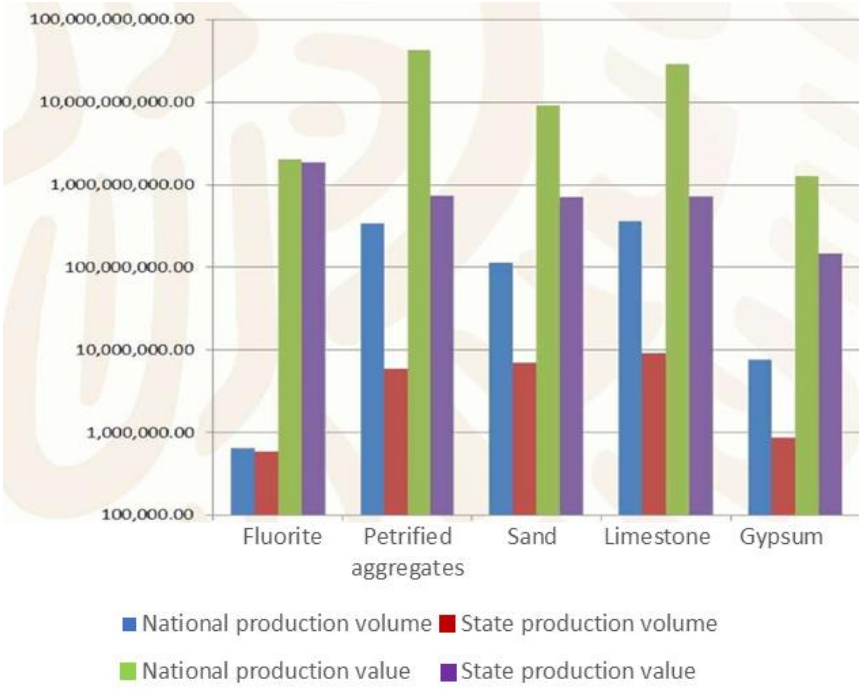


Source: Own preparation based on Mexican Geological Survey (SGM, 2019).

The data presented show the importance of the metal sector in the state, the economic participation by its level of production, places it as a significant mining-metallic state, since in addition, the data presented belong to 6 of the 16 minerals of which Mexico is the main producer worldwide (SGM, 2019). The volume data also express the economic value of each metal.

Table 4: Participation of Non-Metallic minerals of San Luis Potosi in national production's volume and value

Products	National production volume	State production volume	National production value	State production value	Percentage
Fluorite	1,959,089.22	1,862,458.00	6,320,409,893.46	6,008,658,436.37	95.06
Petrified aggregates	635,445,047.65	19,641,345.75	88,602,619,442.13	2,738,672,845.50	3.09
Sand	212,732,879.22	25,409,653.43	22,889,206,807.15	2,831,182,062.46	11.94
Limestone	355,592,001.50	9,976,542.64	76,682,194,323.43	2,161,627,471.21	2.80
Gypsum	11,202,792.55	866,759.31	1,875,993,336.42	145,145,478.85	7.73



Source: Own preparation based on Mexican Geological Survey (SGM, 2019).

3.1 Economic use of the mining-metallurgical industry in San Luis Potosi

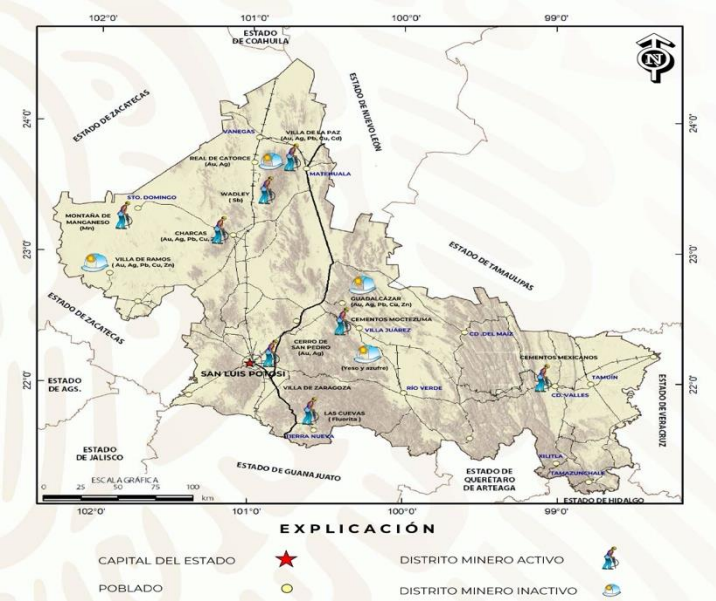
The benefits that the Mining-Metallurgical Industry has in the state, are important in the contribution of economic factors, in addition to this spill offers great goodness to society. The working indicators are a sample, being a state considered mining by the extent of its deposits.

For the value of mining-metallurgical production, the state ranks sixth nationally. In the production of metal minerals, influencing these positions as fundamental values the market quotes of each ore, having achieved an uptick in the value of mineral production of the order of $12,452'472,838.72 recorded in the state in 2016 as a

reference (SGM, 2019).

There are inactive mining districts with good economic ore potential in the entity, such as the "Real de Catorce", "La Maroma" and recently “Minera San Xavier” among several others, which require prospecting studies in order to make feasible their future exploitation whose suspension of activities were due to causes other than the depletion of the mineral potential.

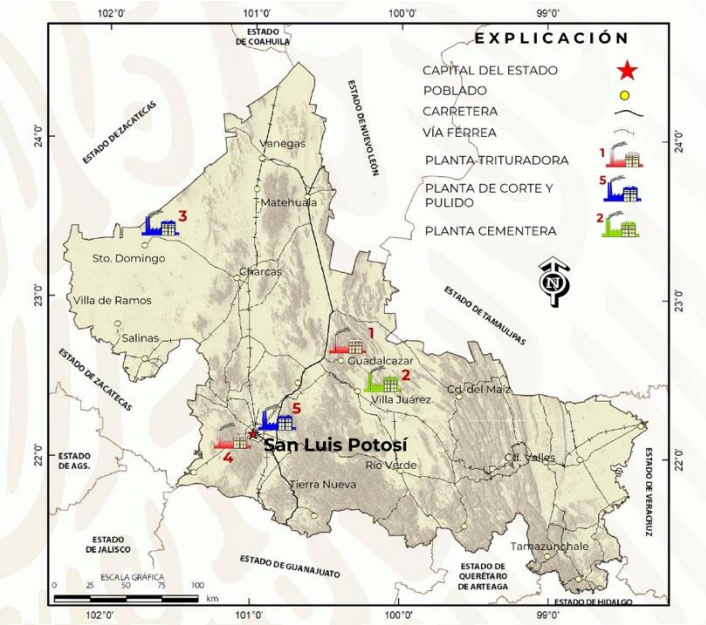
Figure 11. Mining Districts in San Luis Potosi



Source: Mexican Geological Survey (SGM, 2019).

Table 5: Metallurgic and transformation mining units in San Luis Potosi - Non metallic

No.	COMPANY	PRODUCTION	SUBSTANCE	PROCESS
1	CIA, TRIYESA S.A. DE C.V.	VARIABLE	GYPSUM	TRITURATION
2	CEMENTOS MOCTEZUMA	6500 t/d	CEMENT	CALCINATION
3	HERMES BETANCOURT	125 m^3/d	ONIX-MARMOL	PULISH AND CUT
4	SAINT GOBAIN, S.A. DE C.V.	200 t/d	GYPSUM	CALCINATION
5	MEXICHEN, SERVICIOS FLUOR S.A. DE C.V.	1890 t/d	FLUORITE	GRINDING AND FLOTATION



Source: Mexican Geological Survey (SGM, 2019).

3.2 Communication and Access Roads:

Important for mining development is terrestrial communication that supports access to deposits and mineralization prospecting, as well as the trawling of mineral products for marketing either raw and/or mineral and treated at the profit plants of existing deposits. The network of roads of the entity consists of 12,147 kilometers, of which 3,103 kilometers are paved, 6,800 km are coated and 100 km are dirt road; the conservation of all of them is carried out by the Secretary of Communications and Transport as well as the local road board, which allows to have an adequate connection to the interior of the entity as for the rest of the country and centers of marketing and smelting of minerals.

Highway 49 connects the city of San Luis Potosi with the cities of Zacatecas and Torreon, a route that gives access to the MSJ mine treated in this report. It communicates with Highway 45, Mexico, Cd. Juárez, in addition there are state roads that connect with each other to other cities of the state and neighboring states, covering most areas of interest in mining matters.

The railway network of the entity has a length of 1,279 kilometers. This railway line currently provides cargo service, used for bulk ore trawling and selected and/or packaged, crossing the state from North to South bound for Mexico to Nuevo Laredo

at its ends. There is rail transport from San Luis Potosí to the port of Tampico and Tuxpan Veracruz, and the service of the city of San Luis Potosí to the cd. De Aguascalientes. Being able through this section, make connections with the Mexican railway to the border of Cd. Juárez with the United States.

The state has an international airport located near the city of San Luis Potosí, which serves as the state capital, a domestic airport in the municipality of Tamuin and several smaller airports in the rest of the state.

Figure 12. Communication routes in San Luis Potosi

Source: Mexican Geological Survey (SGM, 2019).

3.3 Geology of the region.

The territory of the state comprises three physiographic provinces: Sierra Madre Oriental, Mesa Central and Gulf of Mexico Coastal Plain, of which the Sierra Madre Oriental occupies the largest territorial extension.

Within the regional geological framework, it occupies a portion of the Paleogeographic Unit, called Mesozoic Basin of Central Mexico (Carrillo, 1971), where there are marine deposits from the Triassic to the Cretaceous. This basin includes part of the geological provinces: Valles-San Luis Potosí Platform, Mexican Fold Belt, Mexican and Zacatecan Ignimbritic Belt (Ortega, 1991).

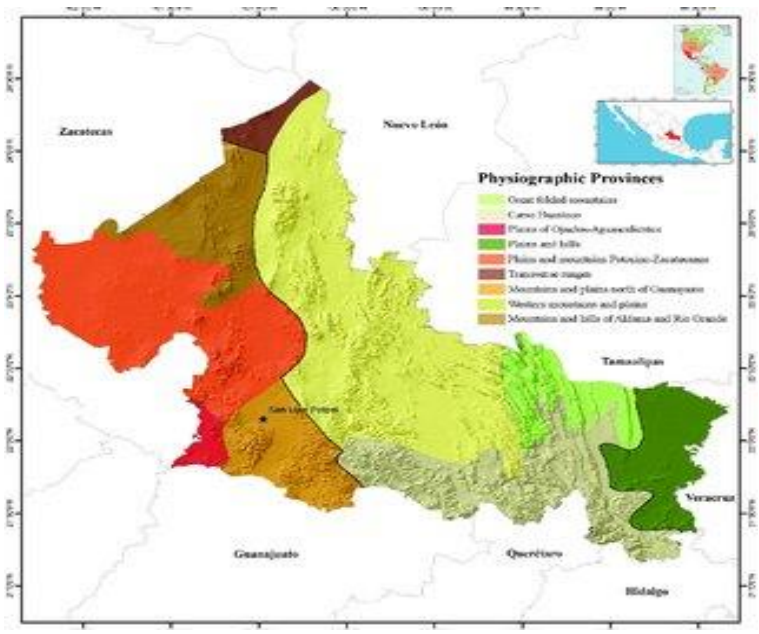
The Valles-San Luis Potosi Platform region is characterized by isolated elevations with relief that corresponds to volcanic and sedimentary plateaus, low rolling plains, swampy areas and alluvial valleys.

The Mexican Belt is identified by an abundance of folds, whose symmetry axes present a general NW-SE and N-S orientation, some of them affected by reverse faults or thrusts, which are the result of subductive processes in the western part of the continent, from the late Cretaceous and early Tertiary. The Cenozoic Mexican Ignimbritic Belt of continental origin includes some of the most widely distributed stratigraphic units in Mexico, such as the ignimbrites of the Sierra Madre Occidental; undoubtedly the most extensive and spectacular volcanic sequence in Mexico, deposited in tensional basins.

In general, Mexico, on its territorial surface, presents natural riches expressed in landscapes and deposits rich in vegetation, climate, fauna, minerals. San Luis Potosí, by this location, contains much of these resources, in such a way that research in the field of sustainability, is important, significant, relevant and orginal, in promoting care for a non-renewable resource.

The following Figure (13) provides for resource-rich and relevant state physiography for conservation studies:

Figure 13. Physiographic provinces



Source: Mexican Geological Survey (SGM, 2019).

3.4 Electricity

The important supply of electricity for mining operations in the state is generated in five plants that operate interconnected with the national system, being three hydroelectric plants: El Salto in Cd. Del Maiz, with a capacity of 18 megawatts, Micos and Cd. Valles with a capacity of 1 megawatt each, as well as the thermoelectric plant of Villa de Reyes with 750 megawatts and the internal combustion plant of Matehuala that generates 9 megawatts.

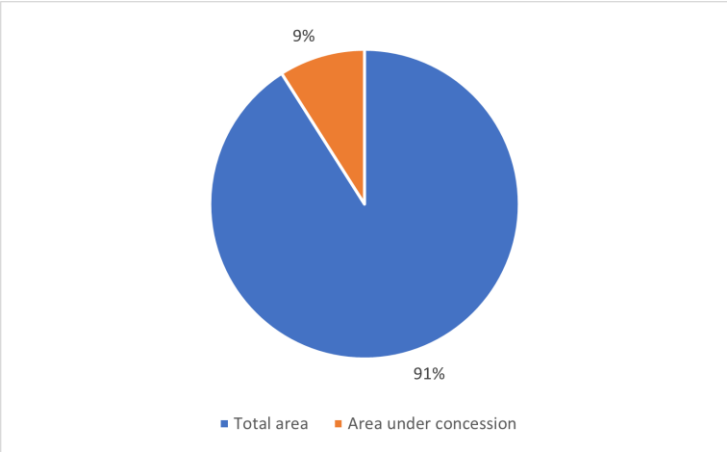
The national high voltage transmission lines (115 - 230 Kv), makes possible the distribution throughout the state for domestic and industrial service covering most of the deposits of the entity.

In this way, San Luis Potosí, is an autonomous state, which produces the electricity it requires in its various industrial and social sectors, and that also generates for the rest of the country, a condition that expands the participation of investment in the mining sector.

3.5 Mining Properties [Fundos]

Currently the state has 643 titled claims covering an area of 640,919.6076 hectares (Servicio Geologico Mexicano, 2019).

Figure 14. Percentage of area in San Luis Potosi under mining concession



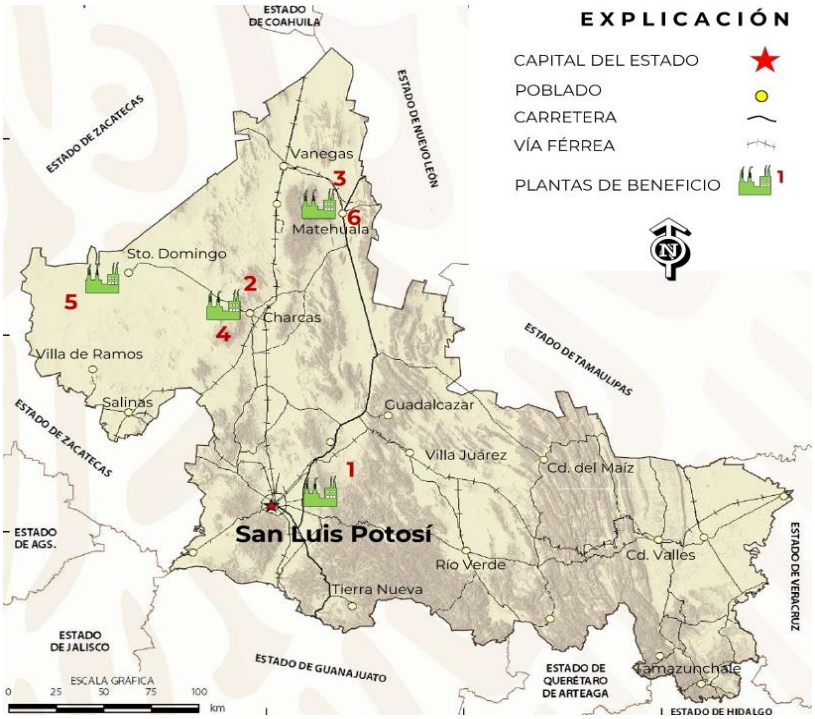
Source: Mexican Geological Survey (SGM, 2019).

3.6 Beneficiation Plants

In the state there are beneficiation plants operating in the vicinity of the mines in operation, with capacities matched to the extraction capacity of the mine, given by the characteristics of the deposits, the equipment and the investment applied as appropriate to determine the production.

The Secretary of Economy of the state together with other related mining support organisms have sought to make agreements with companies that have their profit plants so that they can receive and process ore from small mines that do not have their own processor, having no encouraging results as it is difficult to stop operation, clean equipment and carry control over their own and non-own ore and with strong variants in reagent consumption , release of particles that together with other characteristics and typical of the mineral and its correct process reflect metallurgical recoveries that can cause control problems and results with reflections in conflicts.

Figure 15. Location of the Beneficiation plants in San Luis Potosi



Source: Mexican Geological Survey (SGM, 2019).

3.7 Exploration

When analyzing the surface of the concessional state, and correlating the importance of the geological environment of the entity, it is obvious that there are projects in regions conducive to the mineralization of metallic and non-metallic, so San Luis Potosi, represents an opportunity to find deposits that are susceptible to generate mines and profit plants in regions of abandoned minerals (there are several closed because of the Mexican revolution), and in regions not yet studied and detected by geology and its mineralization environment.

Table 6. Companies exploring in the mining sector in San Luis Potosi

No.	COMPANY	ADRESS	ACTIVITY	SUBSTANCE
1	YESERA MONTERREY S.A. DE C.V.	SERAFIN PEÑA No.938 CENTRO, NUEVO LEON. TEL 52-81-83451122	EXPLORATION, GEOLOGY AND SAMPLING IN VILLA JUAREZ	GYPSUM
2	MINERA LOS LAGARTOS S.A. DE C.V.	MINA PROAÑO, CENTRO C.P.98000. TEL 01-492-9232086	EXPLORATION AND SAMPLING IN LOTE NUEVO MUNDO FRACC 1 AND 2	EVERY SUBSTANCE
3	MICROTALC, S.A. DE C.V.	EJE 104 No.150 CP.7890 S.L.P. TEL 444-8249734 AND 8132541	EXPLORATION IN LOTES SATARA 1 AND 2 IN REAL DE CATORCE	EVERY SUBSTANCE
4	IGNACIO AGUAYO E ING. ALFREDO PÉREZ RASCÓN	FAMILIAR ADRESS IN VILLA DE JUAREZ,SLP	EXPLORATION PROYECTO PAOLA IN VILLA DE JUAREZ	GYPSUM

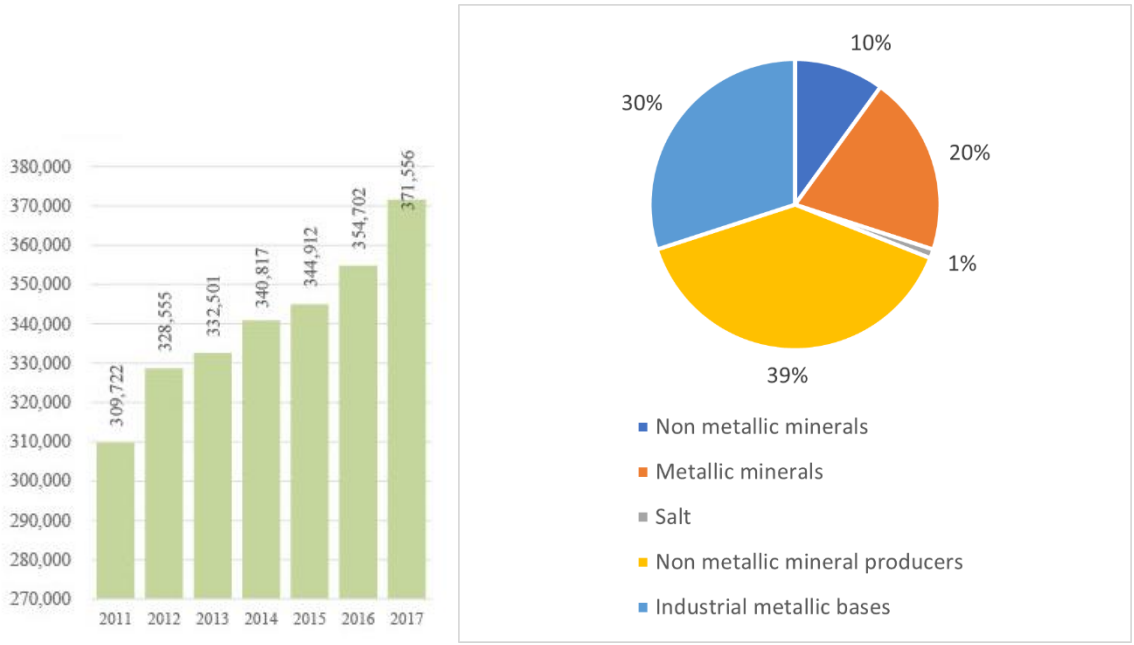
Source: Mexican Geological Survey (SGM, 2019).

Explorations of metallic minerals are carried out by the large producer groups that currently exist in the country, as well as Junior companies that speculate on markets with foreign capital.

3.8 Employment

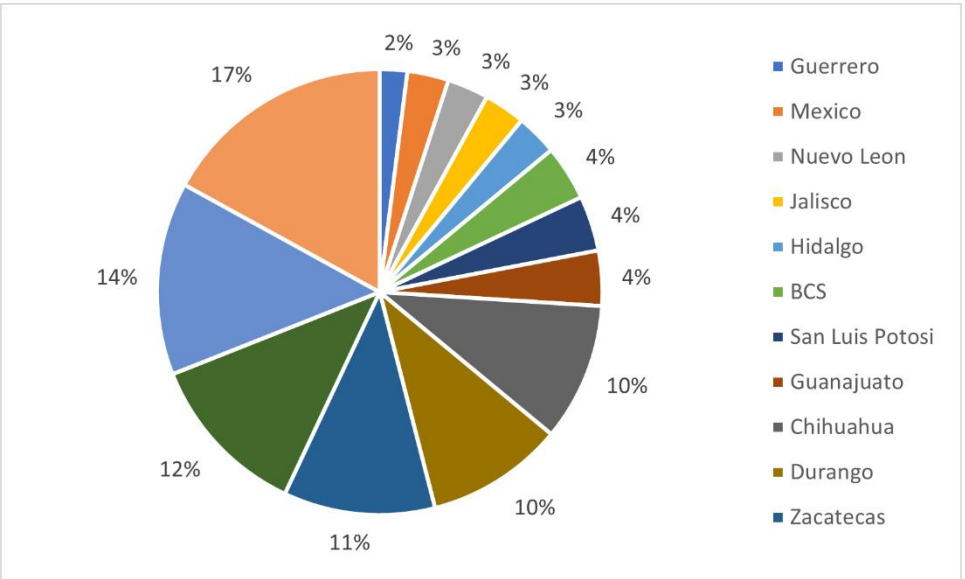
The metallurgical mining sector has been considered an economic factor of importance in areas with interference with this industry, especially because of the effect of being in rural areas and away from the large cities where social satisfiers are accumulated, supporting the economy of the regions where they are installed carrying electricity services, water, communications and other special and essential services.

Figure 16. Employment in the Mining Industry in Mexico



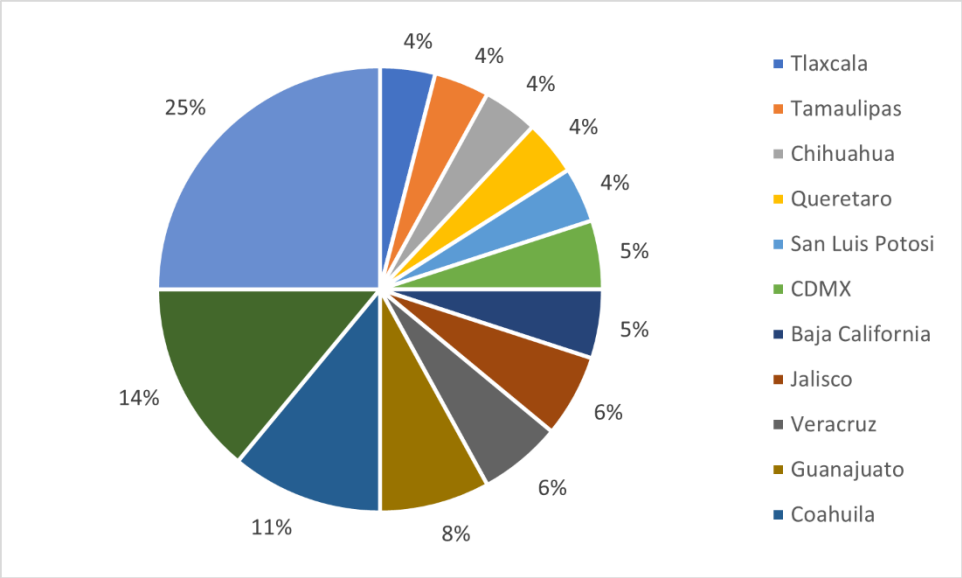
Source: Mexican Geological Survey (SGM, 2019).

Figure 17. Employment in the Mining Industry by state



Source: Mexican Geological Survey (SGM, 2019).

Figure 18. Employment in the Mining-Metallic Industry by state



Source: Mexican Geological Survey (SGM, 2019).

The state has 13,766 direct jobs and 42,890 indirect jobs, with a group of women already active in mining, especially as operators, calculating that this group represents 0.9% of the total population of jobs in the state, representing more than 1.2% in the state of Sonora, because it has a greater supply of jobs as operators in open-pit mines.

Due to the characteristics of the location of the ore deposits, as well as the conformation and need for skilled labor, the daily salary of the mines exceeds the general national average and also corresponds to the average of the industry applied in the entity as it is very representative and quite consistent with the salary figures established and applied in the country.

3.9 Salary

Due to the labor turn, the mining sector is considered "at risk", in addition to the geographical location of the units, which due to the form and naturalness of the mining projects are usually miles away from urban areas; it represents for the human capital, to work outside the cities, abiding by the remoteness even of the family; these factors influence the specialization of professionals in the earth sciences, as well as in various areas of this sector. The salary to which they are entitled for their approach to the units, in addition to their knowledge acquired by way of specialization and continuous training, suggests that it is in good ranks.

Statistically, the salary of an earth science worker in Mexico averages above the national average; in San Luis Potosi this precept is also fulfilled, in addition to presenting higher salaries compared to the same mining sector in national reference and being the metal sector one of the ones that occupies better places, as shown in Table 7:

Table 7. Average daily contribution salary by sector and branch of activity (Pesos)

Sector / Branch	2010	2011	2012	2013	2014	2015	2016	2017
National	**236.5**	**249.3**	**260.1**	**268.1**	**280.9**	**293.8**	**318.7**	**334.2**
Metallurgical mining	318.04	335.6	356.5	374.8	396.6	413.4	433.2	450.4
11. Carbon and Granite	231.8	253.2	277.6	308.9	316.8	336.3	343.2	358.1
13. Metallic minerals	383.6	410.2	435.5	452.2	494.4	516.6	542.9	575.4
14. Salt	417.8	440.9	466.2	511.2	557.7	596.9	624.6	642.9
33. Non-metallic mineral's product	291.6	302.5	314.5	325.3	339.1	351.5	372.8	392.2
34. Basic metallic industries	362.2	371.2	393.5	411.8	434.9	452.2	468.1	470.6

Source: Mexican Geological Survey (SGM, 2019).

4 Originality of the Thesis; Reflections

4.1 About San Luis Potosí and its importance as a Metallurgical Mining State in Mexico

The mining-metallurgical sector accounted in Mexico for 8.2% of industrial Gross Domestic Product (GDP) and 2.4% of GDP according to figures from the National Institute of Statistics and Geography (INEGI), in 2018. As of January 2020, it generated 381,456 direct jobs and generated more than 2.3 million indirect jobs, according to the report of the Mexican Institute of Social Security.

The state of San Luis Potosi and its mining, develops projects that promote or continue to place Mexico as the main producing country worldwide; data are described in particular, in this chapter, which aims to demonstrate the importance of selecting a mine with metallic production from the state of San Luis Potosí, as the object of study of this Doctoral Thesis.

The originality of the research also lies in the connection of current issues for its urgent implementation, such as Sustainability, which promotes the guarantee of natural resources for future generations without sacrificing those present. San Luis Potosi, in its continuous extraction of non-renewable resource, contributes to the wear and tear of minerals and in itself, from deposits, so it is essential, to contribute to deep and specific studies, on how they collaborate with the intention of aligning themselves with the global statutes of environmental care and natural resources, as suggested by the Sustainable Development Goals documented by the United Nations through its 2030 Agenda.

The following points are concentrated, based on the information provided in this chapter, to highlight the importance of San Luis Potosi, in Mexico's mining-metallic sector:

1. The geological environment is favorable for the mineralization of metallic minerals, protruding Copper, Silver, Gold and its natural components such as Lead and Zinc. On non-metallics it presents geologically good trends, including that it has the largest Fluorite production mine, not only from Mexico but globally.

2. The state has sufficient network of land roads and rail support, which facilitates the communication, trawling of minerals and the supply of the necessary inputs for the industry.

3. Specialized labor is another advantage, as the entity has a mining history of great historical significance by having deposits dating from the conquest, some of which are still in operation and staff have been forged in the middle having specialized in new techniques of advancement in both equipment, new operating systems and advanced metallurgical techniques.

4. The vast territory that has not yet been explored in regions with potential characteristics of mineralized areas, is an extremely important attraction for the entity, so investment is required in this area, this in conclusion to the territory and area currently granted in relation to the trend of appropriate mineralization that falls to the state.

5. The services necessary for the operation along with the access roads, exist in the entity without having to locate for example large extensions with electric transmission lines, as well as that there is the installed capacity to grow the industry without major problems. With regard to water for operation the subsoil has adequate properties to have good water supplies with springs and favorable hydrology, as well as the average rainfall recorded and reservoirs to protect rainwater.

6. There are already established government units in the state with favorable plans to boost the extractive industry, with technical and financial support, adding the legal aspect to complement attractive points towards mining.

7. Nationally, San Luis Potosí ranks seventh in the Value of Mining-Metallurgical Production; its production is 15 billion pesos, including Concessible Mining, Non-Concessible Mining and Social Mining (2017-2018), generating a register of 5,000 formal jobs that are expanded up to 13,000 for activities related to this production.

4.2 On the importance and relevance of environmental topics in the generation of management strategies to follow national and international guidelines and public policies within the Mining-Metallurgical Industry of Mexico.

This research its originality on the basis that is expressed by resorting in its development to important international environmental suggestions and implications, such as the Agenda 2030 documented by the United Nations in view of the urgency of developing sustainable programs to vindicate actions that have been demerited against non-renewable natural resources.

The relevance of this study is to propose an alternative way to study economic activities in order to identify areas of opportunity that will allow these activities to operate in a more efficient and competitive manner through the industrial cluster approach

This investigation presents a way of evaluating environmental practices which will guarantee the mineral resource for future generations in developing countries like Mexico throgh the principles of Sustainability (PNUMA, 2010).

It is considered as a proposal for evaluating Mexico's environmental practices through a model for measuring the performance of the Metallic Mining Industry, while focusing on its Sustainable foundations. Additionally a set of reccomendations is put forward to handle the implementation of a Model of Sustainable Management in the Metallic Mining Industry.

The originality of this implementation proposal within the Metallic Mining Industry (silver) supports the possibility of extending it to the Metallic Industry and to other entities of the country. This research lies in the connection of international environmental topics with the practices of mining-metallurgical units, in order to represent reality.

The research focuses on Sustainability Principles to deepen Environmental Management practices, which have been involved in ecological and social problems due to the aggressiveness of their processes. The Thesis proposes a Sustainable Model that allows the description of environmental practices in Mexican mining units, from a global reference.

The research brought recommendations as areas of opportunity based on the best practices observed in the units of analysis. This mean that it is a proposal for the mining sector, which is flexible for other industrial sectors and even for other nations. These facts presents a Thesis that brings new research lines in relation to the study of Sustainability in the mining-metallurgical sector in Mexico.

4.3 About the analysis study that originates within Chapter II, after its point 4 presents environmental models in force in Mexico that have been adapted.

Based on the information provided in this chapter, this research is considered original, due to the scope, literary contribution and scientific method used in function of environmental issues in an operational Sustainable Management Model implemented within this industrial sector, promotes a contribution that is based on legislative regulations of the nation and that takes as a guide the international suggestions to operate in favor of the environment.

In this quest to operate without damaging the environment, within the mining sector, foreign models have been adopted that serve as pillars of administrative strategies with different topics to solve: quality, human, technical, safety and hygiene factors, logistics, environmental, among many others, obtaining from these, few or no effective results, due to various elements on the part of workers , management areas and by the model itself, which is far from considering the idiosyncrasy of the Mexican in its implementation and execution.

These elements not considered, entail in themselves, organizational analyses that have not arisen either, emerged the expected effect and the appropriate response on the part of the authorities of organizations and companies, since the imposition of adopting the model or models is required as a factor of competitiveness and equivalent of order and quality of both the product and the process and even, of the collaborating people (Buenaventura, Gómez and León, 2007).

Foreign models from the point of view or perception of workers, can be understood as a form of taxation of operating mechanisms, revealing themselves as manifestation or intention to carry technical, human or environmental benefits, in such a way that it can be said that they are instruments that facilitate the integration of markets; it constitutes a technical barrier that ensures segmented control in global

form by different organizations, especially in regions, countries, continents that originate in developed economies (Buenaventura, Gómez and León, 2007).

On the other hand, the pressure of the process of internal diffusion of the models that arrive in the country, promote them to the medium and small industry, where their structure could be inadequate for them to develop dynamics of organizational culture, so that their application can be counter-cultural, causing technocratic processes to limit the response capacity of the organization to the elements present in its social environment (Buenaventura, Gómez and León, 2007).

Presenting a Sustainable Management Model with an operational basis and with rigor attached to the scientific method, formalizes an original research study by promoting pillars of construction with foundation and execution that arises from principles aligned to the legislation itself and parameters known by employees and employers, since the origin is located in the same country and in this way allows the measurement of global principles with formats of insertion and dissemination of results in a loan and optimal way, since they are not considered as foreign tax adoptions, in addition the implementation of this Sustainable Management Model, before its foundation, promotes observing and enhancing the environmental practices that organizations contemplate, without the need for bureaucratic technicalities, which does not involve extra work, but values their activities and creates awareness in others to be executed; its versatility can be extended to the entire metallurgical mining sector of the country.

Studies reveal that the implementation of foreign models (see Chapter II, point 4), direct actions and intentions towards administrative aspects, which leaves aside the effectiveness of these in their final intention, which is in the case of environmental models, the eradication, minimization and / or reversal of environmental impacts; this happening in the search for compliance whether documentary, organizational or executable or dissemination activities and not in those that truly act on the environment.

CHAPTER IV. SUSTAINABLE MANAGEMENT MODEL: *METHODOLOGICAL DEVELOPMENT*

PRESENTATION

The Case Study, Scientific Method used for this thesis, is carried out in a mining unit in the surroundings of San Luis Potosí and Zacatecas in the metallic trend Au-Ag-Pb-Zn. This is a 2016 grant by law to a Canadian corporate belonging to the ASI group, whose acronym in this case is handled as MSJ[11].

At the first part, the methodological design is described. Corresponds to a Simple Case Study of the Holistic type since what this qualitative research seeks is to interpret the organizational phenomena whose complexity requires the interpretation and reconstruction by the researcher as indicated by Mendizabal (1996), Yacuzi (2005) and Yin (1994, 2000) on how management practices are carried out in the Mining-metallic Industry. It is considered a qualitative research, promoting knowledge management within an interpretive constructivist paradigm, which through the participant observation of the researcher, uses instruments built deliberately to get into the reality of a unit of analysis selected for convenience.

The second part describes the process carried out through phases to build data collection tools considering the Sustainable Principles selected: *Industry, Innovation and Infrastructure,* Sustainable Cities *and Communities,* Responsible Production *and Consumption* and finally, *Life of Terrestrial Ecosystems,* linked to the corresponding Mexican legislation parameters. The construction methodology of the Model and its validation supported on the mentioned information that is generated by verifying the proposed criteria described.

The third and fourth parts, presents the Sustainable Management Model, including elements and the qualitative validation, also contained details for the proposed stages for field research and the correspond model justification.

[11] Acronyms are handled to respect the confidentiality of the mining unit subject to this Case Study.

1. Methodological Development description

1.1 Interpretive constructivist paradigm

The constructivist paradigm envisages the generation of knowledge by the use of systematic and systemic methodologies or holistic (Berger and Luckman, 2003). This constructivist approach (Denzin and Lincoln, 2000) allows to know and describe the reality of the environmental practices of the mining-metal industrial sector considered as primary in the national economy, but also because these practices are nuanced by values linked to the environment that can positively or negatively affect the environments where these workplaces are physically located. So the research and interpretation attitude on the part of the researcher promotes the explanation of what happens in terms of Environmental Management in this particular case of underground mine extractor silver and lead.

1.2 Qualitative Research Approach

To understand the Environmental Management of companies in the mining-metal sector, this research is carried out under a qualitative approach due to the complexity required by the analysis of the Case study. Firstly because it is environmental management that is managed in a Mexican mining-metallic sector little explored by the academy. Secondly, because it is assumed that this industrial sector fully complies with international and national environmental standards but that in practice there is the opposite social perception, so it is a complex phenomenon that for its understanding and explanation requires methodological depth, which can be achieved through the qualitative approach. This qualitative research approach favors a theory stance based on environmental sustainability (Sautu, Boniolo, Dale and Elbert, 2005) in order to highlight the facts but also the possibility of interpretation from the perspective of the actors. With the interpretation of qualitative data, it is intended to generate a knowledge with greater theoretical-practical certainty of Environmental Management.

1.3 Simple Case Study, Holistic

In order to answer the questions posed at the beginning of the research, it was chosen to develop a methodological strategy with a simple Holista case study approach to understand how management practices are performed in an underground silver mining unit as a premium product and lead as a extraction by-product. In this way, they are exhibited with a defined protocol, various scenarios in the application of the study, considering a theoretical sample suggested by Yin (2000), Hernandez (2016) and Mendizabal (1996).

1.3.1 Holistic Simple Case Study, Analysis Units

To conduct a Case Study investigation, an exploratory phase is required that empowers the researcher to use an informed selection according to pre-established criteria in order to define the appropriate analysis unit that responds to initial research questions and to meet the objectives set out in advance. Table 8, therefore recovers the main elements that make up the mining-metallurgical sector in general and which served for the sample selection of this Case Study.

Table 8. Description of companies that make up the mining-metallurgical sector for selection of the analysis unit.

Sample selection criteria		Overview
Type of mining-metallurgical units	Mines	Units representative of the sector, for their extraction processes, are considered aggressive and high risk to the environment.
	Refineries	Its existence is less than that of mines, however it represents the metallurgical plane of the sector, have been engulfed in considerable environmental-social problems in the country because of its location near cities.
Type of Mine	Open pit mine	Open pit mines are mining developments on the surface of the terrain, due to the location of the ore. Soil wear or removal is noticeable and high impact, as the landscape changes radically.
	Underground	The mineral deposit is located below the surface of the terrain, so its extraction promotes a sharp exploitation process.
Type of Mineral	Metallic	Non-renewable resource, composed of inorganic matter of defined chemical composition. They do not form rocks and are found in small amounts. Its properties: hardness, brightness, color, conductibility, exfoliation, shape.
	Non-metallic	Non-renewable resource present in large quantities in the Earth's crust. They don't have their own brightness or drive electricity.

Geographic Location	*Metallic* Trend[12]	Areas defined in Mexico, by the type of metal that is in greater proportion.
	Regions (non-metallic)	Area defined for segmentation and localization practicality according to the Mexican Geological Service.
Closing of Operations	Refinery	Metallurgical processes that by their nature include industrial equipment of greater magnitudes and their proximity to the cities has categorized them as contaminants.
	Mine	Extraction and benefit processes that are considered aggressive with the environment. Ecosystem reintegration.

Source: Own elaboration.

In the present project, Case Studies do not require probabilistic sampling but the sample or unit of analysis is obtained from the exploratory phase shown in Table 8 and other criteria such as Permissibility and Opportunity are added to make it possible to form that unit of analysis under the following sample inclusion criteria.

a. Type of unit. Mining-metallurgical units are classified into mines and refineries. For this case study, the mine was selected as an analysis unit for its representativeness in the mining sector, for its silver and lead extraction processes considered to be aggressive and high risk to the environment.
b. Type of mine. Open pit and underground mines are located in this category. For this study, the type of underground mine was selected as a process of exploitation of silver and lead considered as blunt by the extraction method requiring dynamite.
c. Type of ore. Mining-metallurgical production catalogues minerals as precious metals, industrial metals, steel minerals and non-metallic minerals (INEGI, 2021); precious metals include gold and silver. In Mexico, silver production ranks 1st in the world with a 19.8% stake, placing this industry as economically high and relevant to research. In addition, the selected mine has as a by-product lead considered as industrial metal placing in the 5th place in the world with 4.33% stake.
d. Type of deposit. According to mining delimitation they can be classified into sedimentary, hydrothermal, chemical precipitation, endorreic basins. In the present case, the type of deposit is hydrothermal whose classification is due to the depth at which the mineral to be exploited is located and which requires intrusive methods of extraction.

[12] Trend. In the colloquial language of the mining-metallurgical industry, they represent the geographical areas where mining units with metal production are located.

e. Location. By their geographical location, various metal and non-metallic mining regions are catalogued; within the metal mining regions are located San Luis Potosí, Sierra de Catorce, Charcas, Guadalcázar, Ahualulco, Santo Domingo, Villa de Ramos and Vanegas known as *Metallic Trend.* For sample selection for particularizing convenience (Mendizabal, 1996; Yacuzzi, 2005) the Villa de Ramos and Salinas regions were taken, which because of its surroundings make it an organizational phenomenon of complex causality that requires visibility of Environmental Management practices.
f. Permissibility and Opportunity: a unit that agrees to be studied and flexible in programming and providing information.

Therefore, for this Simple Case Study of the Holistic type, the unit of analysis that meets these sample inclusion criteria is considered to be as follows:

Table 9. Selected Sample Unit

Classification	NAME OF UNIT	CORPORATE GROUP	EXTRACTED MINERAL	TYPE OF SITE	TREND/REGION LOCATION
Underground Mine	MSJ	ASI	Silver Concentrate, Lead METALLIC	Hydrothermal	Trend Ag-Au-Pb-Zn Villa de Ramos and Salinas Regions

Source: Own elaboration.

Hence, the Case of Study design has the status of being a Particularizer (Mendizabal, 1996) as to the selected analysis unit; first as it is a sample for convenience for its representativeness in the extraction of silver and lead, secondly because it is a production process carried out in an underground metal ore mine whose Industrial Management must meet international and national standards to achieve environmental sustainability.

1.4 Participatory Observation Technique

To keep track of the organizational phenomenon of Environmental Management in the underground mine, MSJ needs to have an analytical, holistic and comprehensive perspective, hence participatory observation contributes to the research process by paying attention to the details, events, events or interactions that take place in the analysis unit. It is important to note that participatory observation involves the researcher actively both externally and internally (Campoy and Gomes, 2009) in order

to adhere to reality regardless of whether or not the observer belongs to the community where the Case Study is conducted.

1.5 *Informant profile*

a. That belongs to the analysis unit under study.

b. Have a position in the Environment department or program, or have direct responsibility for it.

c. That he is at least three years old in office.

d. Have the availability and willingness to participate in the development of this research.

As a participating observation, there are aspects called "observable or non-observable". Observables are those embodied in some data collection instrument (Hernández, 2014) while the non-observable ones will be those subjective information that underlie the responses or behaviors of the informants (Arzaluz, 2005). Therefore, informants for their role within the investigation are organized into three:

a. Informants for observable aspects: That functions as a guide-companion in the visits of the analysis unit.
b. Informants for non-observable aspects: To serve as an information provider to complement the elaborate deliberately checklist; is responsible for the interpretation of the information collected.
c. Other informants: That they are experts in the mining-metal sector in aspects related to the environment and its management, environmental security to assist in the construction of data collection instruments and technical interpretation thereof.

1.6 Designing instruments for data collection

Three data collection instruments were built: Observation Guide, Checklist and Semi-Structured Interview. For its design it was carried out in six phases considering that the following are described and that constitute an ad hoc methodological proposal that strengthens the environmental management model that arises from this Case Study:

Phase 1. Description of Sustainable Principles (international level). The Sustainable Development Goals (SDGs) from which six points are extracted from the 17 that are handled as they have been considered to be the elements with the greatest influence in the management, monitoring and evaluation of environmental issues and to which companies in the mining sector would have to adhere such as Social Responsibility and Sustainability. Thereafter they will be recognized as *Sustainable Principles,* these are:

(1) clean water and sanitation
(2) innovation industry and infrastructure
(3) sustainable cities and communities
(4) responsible production and consumption
(5) climate action
(6) life of terrestrial ecosystems

Each of these Sustainable Principles should have an orientation towards the mining-metallic sector hence it is necessary to make a second process delimitation for this research, so the principles of clean water and sanitation and climate action are excluded, taking into account that water is a resource on the one hand while within infrastructure, the sustainable community and the life of terrestrial ecosystems can absorb actions towards the climate. This second delimitation proceeds to describe targets for each of the Sustainable Principles that contribute to the understanding of environmental management of the Mexican mining-metallic industry in general and in particular the Case Study of the underground mine located on the *Ag-Au-Pb-Zn trend* in the state of San Luis Potosi. The description of each Sustainable Principle and the goals they pursue are shown schematically below.

Table 10. Sustainable Principles selected for the Mining-Metallic Industry.

Sustainable International Principles		
Principle	**Description**	**Goals that apply to the mining-metal industry**
Industry,	Investing in infrastructure, empowers communities, achieves increases in productivity, income and improvements in health and educational outcomes. Growth and urbanization create the need for new	Develop reliable, sustainable, resilient and quality infrastructure to support economic development and human well-being..
		Promote inclusive and sustainable industrialization; provide financial, technological and technical support.
		Modernize infrastructure and reconvert industries so that they are sustainable, using resources more efficiently and promoting the adoption of clean and

	investments in sustainable infrastructure that allows cities to be more resistant to climate change and promote economic growth and social stability.	environmentally sound industrial technologies and processes.
		Increase small industries' access to financial services, affordable credit, and integration into value chains and markets.
		Increase scientific research and improve technological capacity of the sector.
Sustainable cities and communities	Cities have allowed people to progress socially and economically. The problems of cities are congestion, lack of funds for basic services, housing shortage and deterioration of infrastructure, so their challenge is to face them in order to prosper and grow by making better use of resources and reducing pollution. Cities with opportunities, access to services, energy, housing, transportation and more facilities are required. Cities are characterized by being centers that concentrate commerce, culture, science, productivity, creativity, social and economic development.	Provide access to safe, affordable, accessible and sustainable transportation systems for all.
		Increase inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable planning and management of human settlements.
		Intensify efforts to protect and safeguard the world's cultural and natural heritage.
		Reduce the negative per capita environmental impact of cities, paying special attention to air quality and municipal and other waste management.
		Provide universal access to safe, inclusive and accessible green areas and public spaces.
		Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning.
		Increase the number of cities and human settlements that adopt and implement integrated policies and plans to promote inclusion, efficient use of resources, mitigation of climate change and adaptation to it.
Responsible consumption and production	Promote efficient use of resources and energy, sustainable infrastructure and facilitate access to basic services, ecological and decent jobs, improve quality of life. Applying it helps to achieve development plans, reduces economic, environmental and social costs and increases competitiveness. Create more and better things with fewer resources, increasing net profits by reducing the use of resources, degradation and pollution, achieving a better quality of life. Adoption of a systemic approach to achieve cooperation between participants: companies, consumers, government, organizations, researchers, scientists.	Achieve sustainable management and efficient use of natural resources.
		Achieve the environmentally sound management of chemicals and all waste throughout their life cycle and reduce their release into the atmosphere, water and soil in order to minimize their adverse effects on human health and the environment.
		Significantly reduce waste generation through prevention, reduction, recycling and reuse activities.
		Encourage large companies and transnationals to adopt sustainable practices and incorporate sustainability information into their reporting cycle.
		Promote public procurement practices that are sustainable, in accordance with national policies and priorities.
		Ensure that people have relevant information and knowledge for sustainable development and lifestyles in harmony with nature.
		Develop and apply instruments to monitor the effects on sustainable development.

Life of terrestrial ecosystems	Promote the sustainable use of terrestrial ecosystems, act against desertification, try to stop and reverse land degradation and halt the loss of biological diversity. Nature, seen as ecosystems, occupies 30% of the earth's surface, which provides food security and shelter, essential to combat climate change, by protecting biological diversity. The challenges for sustainable development are deforestation and human desertification, through the restoration of ecosystems.	Ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and arid areas.
		Promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and significantly increase afforestation and reforestation.
		Fight desertification, rehabilitate degraded lands and soils, including lands affected by desertification, drought, and floods, and strive for a land degradation-neutral world.
		Take urgent and meaningful measures to reduce the degradation of natural habitats, halt the loss of biodiversity, and protect threatened species and prevent their extinction.
		Integrate the values of ecosystems and biodiversity in planning, development processes, poverty reduction strategies and accounting.
		Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems.
		Mobilize considerable resources from all sources and at all levels to finance sustainable forest management.

Source: Own elaboration based on the 2030 Agenda SDS.

Phase 2. Description of actions that generate risks of impact and environmental impact in relation to the Sustainable Principles. The mining-metallurgical sector is composed of a diversity of production processes whose own characteristics lead them to generate risks of impact or environmental impact so this phase of design links them with the Sustainable Principles in order to build a methodologically robust and reliable data collection instrument. This linkage identified the following actions that generate risks of impact and environmental impact in four stages of the production processes that are generally shown in the mining-metallurgical sector.

Table 11. Risk-generating actions of impact and environmental impact in stages of the production process in relation to sustainable principles.

Sustainable Principle	Stages or production process of the mining-metal sector			
	Exploration	Mining Operation	Benefit	Remediation
Industry, innovation and infrastructure	1. Construction of roads for exploration machinery. 2. Construction of Squares. 3. Use of water.	1. Movement of material in the open sky and in underground developments. 2. Formation of terraces 3. Formation of “tepetateras”.	1. Obtaining tailings as waste. 2. Use and containment of chemical reagents. 3. Overuse and contamination of water. 4. Spills.	1. Technical studies and incomplete supervision. 2. Standards not met

	4. Maintenance of equipment in the field, use of supplies.	4. Construction of workshops for services.		
Sustainable cities and communities	1. Construction of roads and passages. 2. Limited economic resource and on the other hand, not limited.	1. Creation of non-governmental organizations (NGOs). 2. Use of explosives without prior technical studies. 3. Construction of roads without considering populations.	1. Creation of non-governmental organizations (NGOs). 2. Small miners without economic resources do not support the community.	1. Creation of non-governmental organizations (NGOs). 2. Limited financial resources do not support community.
Responsible consumption and production	1. Movement of material by exploration work. 2. Touching the water table.	1. Construction of ports. 2. Construction of underground mine shafts. 3. Construction of sinkholes. 4. Extraction of gases into the atmosphere.	1. Excessive water consumption. 2. Storage of obsolete reagents in the mill and laboratories.	1. Water pollution. 2. Construction of tailings dam without slopes
Life of terrestrial ecosystems	1. Construction of roads. 2. Construction of squares. 3. Use of oils.	1. Formation of terraces. 2. Formation of "tepetateras". 3. Construction of ships: infrastructure.	1. Obtaining tailings as waste .	1. Construction of Infrastructure. 2. Insufficient or no financial programming for closure and remediation stages.

Source: Own elaboration based on information endorsed by Martinez (2019) mining expert during semi-structured interview.

In particular, for the Case Study of the MSJ underground mine as they are productive processes of both exploitation and benefit within the mining-metal sector and its linkage with the Sustainable Principles it is obtained that the risks of impact and environmental impact are characterized as described below:

Table 12. Actions generating risk of impact and environmental impact in the stages of exploitation and benefit of the MSJ underground mine and its linkage with the Sustainable Principles.

Sustainable Principle	Exploitation	Benefit
Industry, innovation and infrastructure	1. Displacement of material in underground developments. 2. Earth formation 3. Formation of "tepetateras" (waste mountain). 4. Construction of workshops for services.	1. Obtaining pulls as waste. 2. Use and containment of chemical reagents. 3. Overuse and water contamination. 4. Spills.

Sustainable cities and communities	1. Creation of Non-Governmental Organizations (NGOs). 2. Use of explosives without prior technical studies. 3. Construction of roads without considering populations.	1. Creation of Non-Governmental Organizations (NGOs). 2. Small miners without financial resources. They don't support community.
Responsible production and consumption	1. Construction of lightheads. 2. Construction of underground mine shots. 3. Construction of under no-goers. 4. Extraction of gases into the atmosphere.	1. Excessive water consumption. 2. Storage of obsolete reagents in profit plant and laboratories.
Life of terrestrial ecosystems	1. Earth formation. 2. Formation of tepetateras. 3. Construction of ships: infrastructure.	1. Obtaining pulls as waste.

Source. Own elaboration from the delimitation of impact and environmental impact risks for the Case Study.

In addition, the participation of expert informants in mining and environmental management provide additional elements to identify the risks of environmental impact and impact generated in mining units that are linked to the Sustainable Principles as detailed below in the table below.

Table 13. Additional elements to identify impact and environmental impact risks for underground mine production sector linked by Sustainable Principle.

Industry, innovation and infrastructure	**Sustainable Cities and communities**
5. Construction of roads for exploration machinery. 6. Construction of squares. 7. Maintenance of equipment in the field, use of supplies. 8. Displacement of material in open pit and in underground developments (earths and tepetateras). 9. Construction of workshops for services. 10. Obtaining pulls as waste. 11. Use and containment of chemical reagents. 12. Overuse and water contamination. 13. Spills. 14. Technical studies and incomplete supervisions 15. Standards not met.	1. Construction of roads and steps without considering populations. 2. Creation of Non-Governmental Organizations (NGOs). 3. Use of explosives without previous technical studies 4. Limited economic resources – not community support.
Responsible production and consumption	**Life of terrestrial ecosystems**
1. Displacement of material by exploration site. 2. Play groundwater level. 3. Construction of lightheads. 4. Construction of underground mine shots. 5. Construction of under no-goers.	1. Road construction. 2. Construction of squares. 3. Use of oils. 4. Earth formation. 5. Formation of tepetateras.

6. Extraction of gases into the atmosphere. 7. Excessive consumption and water contamination. 8. Storage of obsolete reagents in profit plant and laboratories. **9.** Construction of jales dam without slopes	6. Construction of ships: infrastructure. 7. Obtaining pulls as waste. 8. Insufficient or no economic programming for closing and remediation stages.

Source. Own elaboration from semi-structured interviews conducted with expert informants for this Case Study.

Phase 3. Description of environmental parameters according to Mexican legislation (national level). The analysis of literature regarding environmental legislation in Mexico channels the environmental aspect in impact mitigation, being documents of the report type, which companies in the sector are obliged to present to agencies belonging to the government sector, for evaluation and monitoring in practice or operational life. For the purposes of this work, within Mexico's legislative framework, the basis for identifying indicators is the Environmental Impact Manifestos (EIM).

The EIM´s involve technical studies, which give rise to the document, which describes in detail the environmental conditions prior to the realization of any mining project, covering the four seasons of the year, in order to evaluate potential impacts on flora, fauna and the environment, as well as describe the proposals for the necessary measures to prevent, mitigate or compensate for such alterations (SEMARNAT 2013, cited in Martínez y Rivera, 2018); this document is regulated by the Federal Attorney General's Office for Environmental Protection (PROFEPA). It consists of eight sections (Martínez y Rivera, 2018), which contain according to the stage or process of the mining-metallic project (exploration, exploitation, profit, remediation and closure), indicators to be described and evaluated as determined by the agencies responsible.

They were obtained from this cabinet work, an information matrix containing the qualitative type indicators, which were extracted from EIM´s after describing them as activity and relating them to the impact influence on the environment that each productive stage of the sector in question exposes. For this research these indicators are called Environmental Parameters that generally improve the transferability of mining practices in terms of Environmental Management whose description detailed below (table 8).

Table 14. Selected environmental legislative parameters.

Enironmental Parameters	Description of the Enironmental Parameter according to the EIM
Useful lifetime	The stages are described with justification and precision, this entails planning at the time of finalizing productive activities and managing according to the proposed roads and feasibility, according to the context and location of the mining unit in any of its processes.
Technical responsible	It is required to have a specialist to carry out the study that will endorse the EIM to be presented. This ensures that the remediation is reliable when carried out by a person who concentrates their activities on processing.
Proyect Nature	It must be justified if it is a new mining work, expansion, extension, modification, replacement, rehabilitation of infrastructure, in order to identify present and future environmental elements. Also indicate the stage of the mining process in question: exploration, mining operation, benefit, remediation or closure.
Dimensions	Specify the total area, it is necessary to consider the entire territorial extension, to describe the possible risks that are run: rivers, mountains, valleys, lagoons and document it to mitigate the impact in the remediation stage.
Land Use	It is required to specify the land use of the area: agricultural, livestock, forestry, human settlement, industrial, tourism, mining, protected, without obvious use; regarding the states of water: public supply, recreation, fishing, aquaculture. With this, it is expected that the alteration suffered will not essentially modify the ecosystem, neither during the operation nor in the remediation.
Urbanization of the area	Availability of basic and support services in the vicinity. Manage the operation to obtain infrastructure, build it or operate it. Access roads, drinking water, electricity, drainage; waste water treatment, telephone lines.
Site preparation	Describe in detail and objectively the design of each of the stages of the mining process, to know and associate the effect of the selected design with the reduction of damages to the environment and the remediation that will take place in order to mitigate or avoid impacts.
Construction of works	Describe in detail the works to be built in each stage of the mining process, since it will have to be considered when remediation arrives, the recovery of the territorial extension, the use of land and water sources. In this way, the remediation of trenches, tunnels, wells, pits, powder magazines, deposits of inert and fertile material, leaching patios, tailings dams will be analyzed in detail, among others of the operative type. polvorines13,
Operation and Maintenance	Description of facility operation and maintenance programs, including type of services provided, technology related to the emission of and control of liquid, solid or gas wastes, type of repair to systems, equipment, weed control, noxious fauna and its control methods.

[13] Polvorines: Place of storage of explosives and artifacts which must meet strict construction and operation requirements (Martínez and Martínez, 2015).

Abandonment	Description of tentative and reality-based programs based on technical feasibility and viable studies. Rehabilitation, compensation and restitution measures will be considered. With this, environmental impacts and availability of resources will be foreseen to carry it out.
Use of explosives	Detail the quantity and territorial extension that will be impacted, since the risks of seismic vibrations that are generated can cause permanent or irreversible damage. In addition, the image that is damaged will be considered in the remediation.
Waste generation and management	This description includes the generation and disposal of solid and liquid waste and emissions, as well as the infrastructure for their management. This item includes sanitary landfills, wastewater treatment plants, recycling, confinement and the sufficiency of these. The territorial extensions that they occupy has a strong impact, since most of the actions will have to be based on this description.
Infrastructure for waste management and disposal	Identify infrastructure services for the management and final disposal of waste in the locality: sanitary landfill, wastewater treatment, separation, management, treatment, recycling or confinement of waste. Analyze if they are sufficient for the present, future demand and even of other projects.
Abiotic aspects	This indicator should describe aspects such as: type of climate, climatological phenomena (earthquakes, for example, to consider the use of explosives), lithological characteristics (vegetation mapping), morphological characteristics (hills, slopes, depressions), relief characteristics (topographic plane), presence of faults and fracturing, susceptibility (earthquakes, volcanoes); hydrological resources in the area (surface and underground). topográfico14, fracturamiento15
Biotic aspects	In this indicator, detailed aspects of: vegetation (indicator representing environmental conditions), fauna (terrestrial, aquatic) should be described. It is not only considered to list them, but to make profound interpretations considering: seasonality (periods of life time), distribution, taxonomic difficulty (species classification).
Landscape	Visibility (topographic aspects: altitude, orientation, slopes), landscape quality (intrinsic characteristics, normally morphological), visual quality (lithology, water bodies), quality of the scenic background (diversity of vegetation, altitude) and, fragility (ability to absorb changes)should be describe in detail.

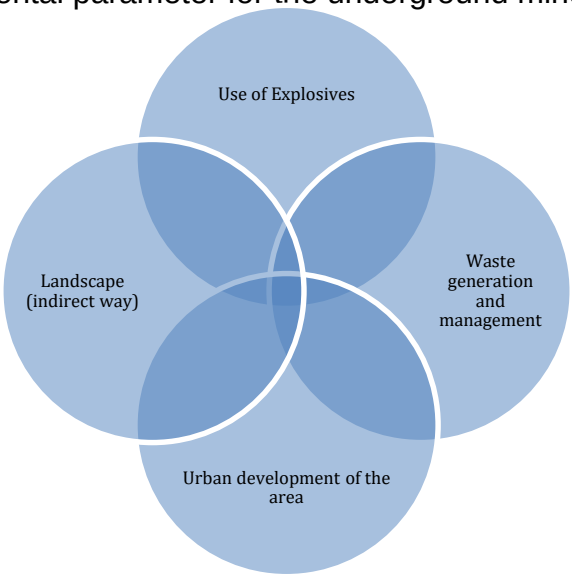
Source: Own preparation based on the EIM guide (2002).

In particular, for the Case Study of the underground mine located *bytrain d Ag-Au-PB-Zn* whose main production is the precious metal of silver the Environmental Parameters are as follows:

[14] Topography: a particularly evident manifestation of variations in age, climate and rock (Duque, 2017).

[15] Fallas y fracturamiento: Release of pressure energy above the plastic limit of the rocks. There is significant displacement of one mass with respect to the other (Duque, 2017).

Figure 19. Environmental parameter for the underground mine production process



Source: own elaboration based on the legislative analysis in force in Mexico (MIA-SEMARNAT, 2002).

Phase 4. Description of actions that generate risks of impact and environmental impact in relation to environmental parameters for the mining-metal industry. A qualitative analysis of the risks of impact and environmental impact is carried out that can arise from the characteristics of each production process of the mining-metallurgical sector within the participatory scope of each environmental parameter. For this Case Study, as it is the mining-metal industry, two stages or production processes have been determined as follows in Table 9.

Table 15. Risk-generating actions of impact and environmental impact at the stages of the production process in relation to environmental parameters.

Environmental Parameters	***Stage or process of the Mining-Metal Industry***	
	Exploitation	***Benefit***
Useful lifetime	1. Determined by exploration and cost-benefit. 2. Production of work material by prolonging life. 3. Team changes of all kinds.	1. It depends on the volume exploited. 2. Wear and maintenance of the equipment. 3. Use of mine supply: water, reagents
Technical Responsible	1. Person with a different profile than a Mine English. 2. Vague continuation of plan and modifications, depending on changes in the characteristics and behavior of deposit, processes, various requirements, international, social, environmental. 3. Attention of the Responsible Ing. to another: congruence, continuity.	
Nature of the project	1. Mine design. 2. Correct operating system.	1. Choice of profit system (floating, cyanuring, concentration by gravity).

Dimensions	1. Expansions required 2. Proportional increase in effects, number of earths, services and inputs.	
Land use	1. Authorities pressured by NGOs.	
Urbanization of the area	1. Population growth. 2. Urbanization extension. 3. Outdated computer involvement.	
Preparing the site	1. Earth formation. 2. Formation of tepetateras. 3. Infrastructure (works, workshops, pipelines).	1. Construction of terraces for different heights. 2. Construction of swimming pools. 3. Infrastructure (plant, laboratories)
Construction of works	1. Construction of hazardous waste warehouse. 2. Dust construction.	1. Construction of working pools. 2. Construction of bases for equipment. 3. Reagent warehouse construction.
Operation and Maintenance	1. Behold space for workshops. 2. Space for patios. 3. Behold ventilation in underground mine. 4. Convertible spaces (open sky).	1. Construction of working pools. 2. Reagent warehouse construction.
Abandonment	1. Seal underground works. 2. Cover slashes. 3. Explosives left over.	1. Allocate yards and equipment bases incorrectly. 2. Partial withdrawal of equipment.
Use of explosives	1. Correct handling of leftovers: SEDENA	Doesn't apply
Waste generation and management	1. Contracts with storage and transport agencies 2. Earth formation.	
Infrastructure for waste management and disposal	1. Contracts with storage and transport agencies 2. Earth formation.	
Abiotic Aspects	1. Location of works based on shooting, underscavones. 2. Location of streams, fractures and geological faults.	
Biotic aspects	1. Contemplation only in EIM. Incomplete. 2. Preventive report. Tracking.	
Landscape	1. Species protection program. 2. Contemplation only in MIA.	1. General view at the foot of the mine.

Source: Own elaboration.

For the reading of this table, it is necessary to consider that the above, causes environmental impact as a result of what is described; in terms of obtaining information from this point, the collaboration of the Metallurgical Mining Engineer, once again, is considered.

Phase 5. Division of Sustainable Principles and Environmental Parameters in observable and non-observable aspects.

According to the methodological design for this Case Study, both the Sustainable Principles and the Environmental Parameters described on previous pages are observable elements in the underground mine analysis unit, hence a checklist or a semi-structured interview is applied. For the classification of observable and non-observable aspects of an adaptation of Leopold's Matrix whose objectivity and operability in the field is noted by the Mining Engineer (Figure 21).

Figure 20. Observable and Non-Observable Aspects.

O – Observables
N - Non Observable
NA – Doesn't Apply

Prinicpios Sustenta ODS	Parámetros Ambientales MIA															
	Tiempo de vida de	Responsable técnic	Naturaleza del proyect	Dimensione	Uso de suelo	Urbanización de área	Preparación del sitic	Construcción de obra	Operación y mantenimient	Abandono	Uso de explosivo	Generación manejo de residuo	Infraestructura manejo de residuo	Aspectos abiótico	Aspectos biótico	Paisaje
Industria, Innovación Infraestructura	N	N	O	O	N	O	O	O	O	O	NA	N	N	N	O	O
Ciudades y comunidades sostenibles	N	N	O	O	N	O	O	O	N	O	NA	O	O	N	O	O
Producción y consumo responsables	N	N	O	O	N	O	O	O	O	N	O	O	O	N	N	O
Vida de ecosistemas terrestres	N	N	O	O	O	O	O	O	N	O	NA	O	O	N	O	O
Observables			X	X		X	X	X			X					X
No Observables	X	X												X		
Divididos					X				X	X		X	X		X	

Source: Own elaboration.

Phase 6. Build data collection instruments. Observation and checklist based on the environmental impact and impact risk-generating actions identified in phases 3, 4 and the phase 5 completion ratio.

There are two principal instruments that were built for this research. At the table 16, they are described in their scope of function.

Table 16. Data collection instruments used in the Simple Holistic Case Study.

Observation guide	Built on elements of international origin based on environmental sustainability and, on significant parameters validated and extracted from government, official and mandatory documents handled by the nation's public bodies; designed to concentrate information on observable aspects (see Annex 3).
Checklist	This instrument attaches the data provided by the informants, developed to select the non-observable aspects to be integrated by their importance, to research, such as programmes and certifications received, their validity and above all, influence they have had on implementation in environmental management practices (see annex 4).

Source: Own elaboration.

2. Construction and validation of the Sustainable Model

The Sustainability Management Model is the theoretical-methodological contribution aimed at companies in the mining-metallurgical sector in Mexico. This model is the result of the construction and validation of data collection instruments used during the Simple Holistic Case Study whose particularizing characteristics enabled the generalization of their components that can be replicated in this sector as a pilot test and from it, regardless of different stages and production processes.

This Sustainability Management Model provides mining-metallurgical sector units with truthful information on environmental management practices, impact risks and environmental impact that are based on current national and international environmental guidelines for this, establish Sustainable Management strategies that favor both procedural operation in mining working methods and action for the minimization and/or eradication of environmental impact risks, which will guide companies towards responsible natural resource care practices to provide subsequent generations with better workspaces and an optimal environment for social and community development.

It is important to highlight the methodology carried out for the design of this Sustainability Management Model which is divided into four stages that are succinctly described immediately:

Stage 1. Theoretical Construction. Having as an analysis framework the updated literature that addresses environmental issues such as Environmental Management,

Sustainability and Sustainable Development, a critical conceptual apparatus is built that forms the theoretical basis of the Model from which it stands out:

Sustainable Development, understood as tangible and practical actions that ensure the correct operational administration and knowledge of the laws of nature, that allow to learn respect for it.

Sustainability, includes aspects such as system management, with a design of equitable systems in the face of the distribution of areas, goods and local decision-making power (Enkerlin, 1997, cited in Reyes, 2019); participates in addition to the strategic planning adhered to business policies and even national and international policies through the legislation of a nation and programs endorsed by bodies such as the UN, respectively.

As a result of the theoretical-conceptual discussion, the following definition is obtained and that forms the conceptual axis for this research:

"Sustainable Development is the operational part, they are objectives, goals and activities structured as tangible proposals, it serves as a guide that systematically obeys guidelines to prevent the deterioration of the environment. Sustainability, for its part, refers to the generation of policies and strategies to pursue and enable the operation and correct implementation of Sustainable Development. Sustainability is attached to Environmental Management, which in turn is aligned with the general management of companies, organizations or corporations" (Martínez, Bednarek, Rivera and Ojeda, 2019).

Stage 2. Universal Principles. The 2030 Agenda sets out the Sustainable Development Goals presenting 17 different expectations containing 169 goals that UN-affiliated countries must seek to meet precisely before 2030 to generate human and evolutionary stability on the planet. From the exhaustive review of this documentation, the dimensions of those aspects directly linked to the Environmental Management applicable to the mining-metallurgical sector are carried out; from there for the Case Study a second dimension is made with four Sustainable Principles remaining as described below:

Industry, Innovation and Infrastructure. Investing in infrastructure empowers communities, achieves productivity gains, revenues, and improvements in health and educational outcomes. Growth and urbanization creates the need for new investments in sustainable infrastructures that make cities more resilient to climate change and drive economic growth and social stability.

Sustainable Cities and Communities. Cities have allowed people to progress socially and economically. The problems of cities are congestion, lack of funds for basic services, scarcity of housing and deterioration of infrastructure, so their challenge is to face them to thrive and grow by making better use of resources and reducing pollution. Cities with opportunities, access to services, energy, housing, transportation and more facilities are required. Cities are characterized by being centers that concentrate commerce, culture, science, productivity, creativity, social and economic development.

Responsible Production and Consumption. Encouraging efficient use of energy resources and efficiency, sustainable infrastructures and facilitating access to basic services, green and decent jobs, improves quality of life. Implementing it helps achieve development plans, reduces economic, environmental and social costs, increase competitiveness. Create more and better things with fewer resources, increasing net profits by reducing resource utilization, degradation and pollution, achieving better quality of life. Adoption of a systemic approach to achieving cooperation between participants: companies, consumers, government, agencies, researchers, scientists.

Life of Terrestrial Ecosystems. Promote the sustainable use of terrestrial ecosystems, act against desertification, tries to stop and reverse land degradation and curb the loss of biodiversity. Nature, seen as ecosystems, occupies 30% of the earth's surface area, providing food security and shelter, critical to combating climate change, by protecting biodiversity. The challenges for sustainable development are deforestation and human desertification, through ecosystem restoration.

Stage 3. Legislative parameters. The current environmental legislation in Mexico is officially set out in the Environmental Impact Manifestos (EIM-SEMARNAT, 2002) that concentrate technical studies on the environmental conditions of operability that

companies in the mining-metallurgical sector must follow under adequate and environmentally friendly quality standards. From these guidelines arise 16 Environmental Parameters used for the Underground Mine Case Study in particular because of this thesis, which will serve for the Sustainability Management Model as an environmental monitoring and evaluation system for companies in the mining-metallurgical sector.

Table 17. Environmental Parameters of the Sustainability Management Model

Usefull Lifetime	**Technical Responsible**	**Nature of the Project**	**Dimensions**
Land Use	Urbanization of the area	Preparing the site	Construction of works
Operation and maintenance	Abandonment	Use of explosives	Waste generation and management
Infrastructure for waste management and disposal	Aspectos abióticos	Biotic aspects	Landscape

Source: own elaboration.

Stage 4. Best practices.

This stage involves field research, which systematically follows the proposed methodology under the Holistic Simple Case Study format resulting in the validation of the Sustainability Management Model in its operational part through the implementation of the Case Study in the underground mine analysis unit with hydrothermal deposit in the productive stage of exploitation/benefit located in trend Ag-Au-Pb-Zn whose extracted ore is Silver and Lead occupying the first and fifth place in production worldwide. This stage consolidates the research project allowing to combine the results of the previous stages with it, finally achieving a global and holistic view of the Environmental Management practices carried out in the Case Study but at the same time, contributes methodologically to lay the foundations of a broader and more comprehensive Sustainability Management Model in terms of scientific rigor and ethical treatment of information. As for its procedural usefulness, it represents the added value provided by a best practice guide that serves to ensure that the management of the mining-metallurgical sector carry concrete and effective actions or programs for the environment.

2.1 Sustainable Management Model Construction

The Sustainability Management Model is based on four pillars: Theoretical Foundation, Sustainable Principles, Environmental Parameters and Best Practices.

Pillar 1. Theoretical foundation. Management, Environmental Management, Sustainability, Sustainable Development Goals, National Environmental Parameters.

Pillar 2. Sustainable Principles. International level, foundation in the SDGs: Industry, Innovation and Infrastructure, Responsible Production and Consumption, Sustainable Cities and Communities and, Life of Terrestrial Ecosystems.

Pillar 3. Legislative Parameters. National level attached to current legislation, based on Environmental Impact Manifestos: Lifespan, dimensions, land use, abandonment, landscape, among others accounting for a total of 16.

Pillar 4. Best practices. Simple case study of a holistic type, implemented as research fieldwork and where practical validation of the Management Model for Sustainability has been generated. It verifies, analyzes, interprets and records data to get those that represent feasible improvements towards the Environmental Management strategy of the analyzed unit, with scope for implementation throughout the metal mining sector and subsequently in the mining-metallurgical sector of Mexico.

2.2 Sustainable Management Model Validation: theoretical-methodological

The proposed Sustainable Management Model is validated to demonstrate its effectiveness, so it was implemented in a unit belonging to the mining-metallic sector through a qualitative cutting research method with methodological strategy of Simple Holistic Case Study applied to an analysis unit that for its particularities is considered predominant in the mining-metallurgical sector already for its industrial processes , for the actions of environmental, economic and social impact generated by its business action within the work space and abroad in the community where the underground mine is physically located. Individual information is complemented and the outcome of best practices is the fourth element of the model. These results will be described in chapters below.

The validation that is based under the qualitative cutting research scheme, includes quality criteria, which are studied and justified (Hernández, 2014). They are described as follows:

Dependence. It is consolidated when experts in the mining-environmental field review, analyze and interpret the information obtained from each analysis unit, having reached consistent and similar interpretations. Second, experts share their interpretations and provide technical observations that constitute the operational description of the analysis of the four universal principles and legislative environmental parameters. His contributions also converge on the description of best practices.

Credibility. Subject to the link of experts who technically support research, with the methodological approach, being their proposals, suggestions and observations about the information obtained in the field, who provide the relevant guidance to avoid trends in the description of what is observed. In reference to the research method, it is the Directors of the University and local advisors, experts in research methodology who promote the quality and validity of constructions and content.

Transfer. Once the Sustainability Management Model has been obtained, with the literary foundations and its operational fraction, it is replicated in the analysis unit selected as the most representative of the mining-metal sector already for its production processes, for the risk of environmental impact and for the economic impact. The possibility of replicating it in more mining-metallurgical units is part of the scope that arises from this investigation.

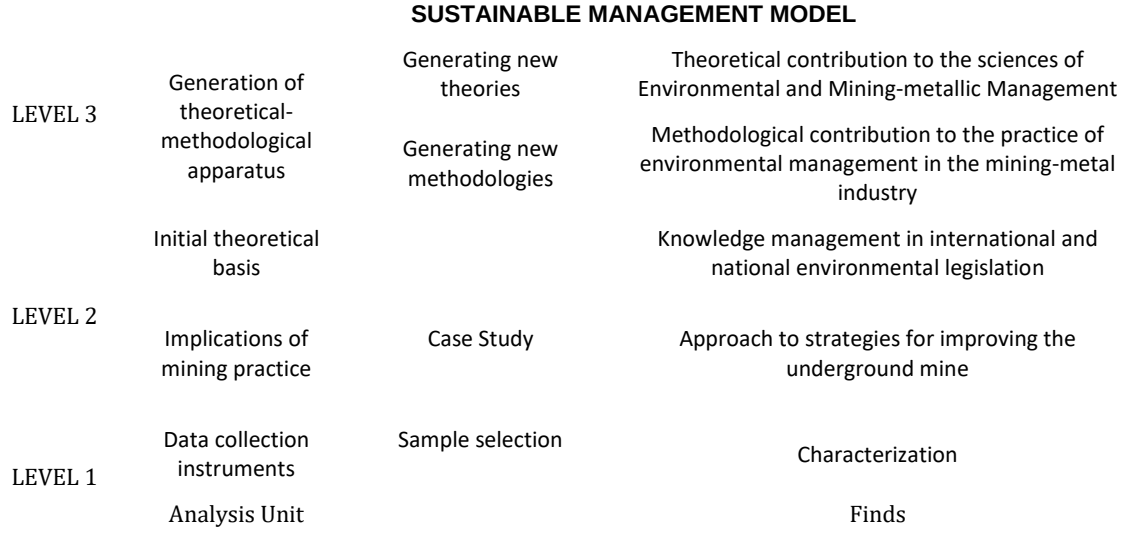
Confirmation. This criterion is justified when the participation of the general managers, chiefs, managers or persons responsible for the "environment" of the analysis units, specifically the obtaining of the information and endorses as true in terms of the responses, the evidence presented and the attitude shown to the interpretations that the researcher and the experts described about the information they provided. The results of the analysis units are expressed in terms of compliance or non-compliance with the Sustainable Principles and the effectiveness of legislative environmental parameters, analyzed from the perspective of observable impacts and un observable impacts. It describes planned and scheduled remediation activities, as

well as the necessary budget items and whether they have been considered over time.

2.3 Fieldwork in Analysis Unit. MSJ Underground Mine

To carry out the development of research through a simple holistic case study, three levels are established that promote the realization and inferences and conclusions at different stages of research (Yin, 2013):

Figure 21. Case study inferences



Source: Own elaboration based on Making Inferences, Cosmos Corporation (Yin, 2000).

Within level 1, the Case Study is developed, where data collection instruments are applied. Based on the information gathered in, interpretations and inferences are obtained that allow the analysis unit to be characterized and data analysis is carried out to reveal the findings of the investigation.

The first level nourishes the second, which begins with the construction of a theoretical-conceptual apparatus and which in conjunction with the first findings are put into play to define the type of environmental impact that is generated in the selected analysis unit. With the triangulation of information, legislative environmental parameters are established that empower the researcher of the theoretical and methodological tools to assess the environmental management practices carried out in the selected mining company (MSJ) and with it, the approach of Environmental

Management strategies that benefit both the practice of appropriate methods and procedures in favor of the environment and surrounding communities.

The third level is the most complex since it involves not only the inference and interpretation of data but a complex scientific reflection that results in the theoretical-methodological proposal with specific implications of Environmental Management in the mining-metallic sector and that can be replicated in various companies in the sector with the procedural variety and processional stages presented by Mexican mining. This theoretical-methodological contribution contributes to Knowledge Management in matters related to Environmental Sustainability and make it an ally for companies in the sector.

2.3.1 Fieldwork in MSJ mining-metallic unit.

The fieldwork consists of four stages that take as a starting point the research questions, the theoretical propositions, the sample analysis unit, the linking of data and propositions and criteria for the interpretation of data.

Stage 1. Pre-operative work. Includes the theoretical-conceptual construct for information collection and programming. Informants were consulted on observable issues for the development of data collection tools. These informants were working at the company in the sector at the time this stage was carried out (2018). During that year, visits were made to various units to establish sufficient criteria for the selection of the analysis unit that would serve the Case Study. Some of the activities carried out during this period were:

a. *Request to mining-metal units –visit, by phone, email, physical. As a strategy to initiate this work, a first approach was* decreed by telephone, in which the researcher presents he/she with a brief context of her intention; it is decided, after this, to send e-mail or physically deliver, an application format to give her formality, which was nurtured in the process by different points of each company, according to her policy to authorize such interventions (see Annex 1).

b. *Approach to schedule visits, establish company and research policies (if required).* Some units, in compliance with their internal policies and regulations, allow access to set dates and schedule them in a personal way,

others require that the approach be via email, in some more it was sufficient to establish contact and agenda by telephone.

c. *Faculty of Social Sciences, extends a formal presentation of the researcher for each analysis unit.* It was given to the company, a cover letter in which SAN promotes as a student of the doctoral program in Management to the researcher, this activity is part, of the formality of the study (see annex 2).

d. *Programming for field work (flexible).* A program is built for each unit, for the realization of field visits, after the application is accepted. In addition, the researcher considers, based on selection criteria and based on observed availability, the unit is selected to perform fieldwork to the MSJ metal unit; it also considers the approximate time and visits to propose to Management as well as to make descriptions to initiate the Case Study.

Stage 2. Fieldwork. It includes the application of created instruments, semi-structured interviews and visits to the analysis unit. The fieldwork formally began in December 2018, once the programming was carried out with the first executable proposals in its facilities and, that these were accepted by management; for the availability of staff and the distance of the location of the metal mining unit, as well as cabinet work and various corrections, the work was carried out in nine months. Some of the most representative activities of this stage were:

a. *Making scheduled visits for fieldwork*. The particular programming is complied with, so that the researcher would cover the relevant visits according to the agenda agreed with the analysis unit. The order of visits is due to the time when the investigator's request was accepted.

b. *Filling the observation guide designed for information.* At first, it was carried out with the advice-company of the assigned informant by the unit, tour of the unit's facilities, covering all processes (exploration, exploitation, profit, remediation) in which the relevant observations are recorded in the observation guide.

c. *Data recording in the structured checklist.* In a second moment, the information called Not Observable was obtained with the informant and with

the Unit Manager, registering the required data in the checklist. The participation of informants by opportunity was also considered.

d. *Semi-structured interviews: informants by opportunity.* The third moment was sought and created spontaneously by the researcher, when by opportunity, informants were identified who provided data relevant to the study in the various visits made.

e. *Approach with experts.* This moment after the collection of data in the facilities of the analysis unit, it verifies the reliability of the information, where it identifies some foreign data, makes suggestions that allow the researcher to rectify with the analysis unit in question; on the other hand it provides objectivity to the observations recorded in the instruments.

f. *Description of the context of the analysis unit.* Search for information in specific places, such as internal libraries of the company itself, databases, to complement the historical and economic phase of the analysis unit.

g. *Concentration of information obtained in the unit***.** This cabinet work, represents for the researcher, simultaneous work with the moments of data collection and description of the context of the analysis units. It contemplates formalizing the holistic case.

Stage 3. Analysis and Results. Once the case is documented, the analysis of the information is carried out together, which promotes a detailed review of the data obtained, the literature that is part of the basis and the review of objectives raised and research questions. Cabinet activities are carried out in which the following are located:

a. *Logical linking of data to propositions.* A cross-report is developed, originating a format from an Leopold matrix, which represents the information generated from the relationship that is made of the principles of sustainability and the data obtained in the fieldwork. Research questions are analyzed and this information is answered.

b. *Interpretation of qualitative data. Approach with experts.* The participation of the expert in the sector, this time corroborates the interpretation of qualitative

data that has been carried out with the linkage of the data to the objectives raised and the relationship that exists with the parameters that are evaluated by the regulatory authorities of the unit on the environment.

Stage 4. Discussion of results. Once the information was obtained from the analysis unit, the data was triangulate, linking it to the elements of the model (conceptualization, sustainable principles and legislative parameters). This activity provided an opportunity to make comparisons in environmental activities and programs, which served to formalize a proposal for a best practice guide.

The interpretation of qualitative data performed and verified by the experts, allows to articulate this work by means of a triangulation: the data obtained, the interpretation that is generated from the mand, the theoretical basis of each Sustainable Principle. Each principle follows this triangulation, so it is in a position to discuss findings interpreted under the sustainable approach of innovation, infrastructure and technology, the development of sustainable communities, responsible resource consumption and the preservation of terrestrial ecosystems.

The discussion goes towards the mining-metal sector, events that promote mitigating impacts on the environment as a result of the processes involved. The Environmental Management practices carried out by the units are evaluated qualitatively to be in a position to develop strategies as alternatives to meet parameters that keep their operability under control and, to generate added value in the action within each of the Sustainable Principles.

3. Sustainable Management Model for the Mining-metallic Industry - Figure

3.1 Sustainable Management Model Elements

The first element that is considered as a theoretical basis, is the discussion between Environmental Management, Sustainability and Sustainable Development. This derives from the possible definitional conflict that these concepts have. In its execution, they can be synonymous, however, in its implementation, Sustainability starts from Management, while Sustainable Development is part of execution.

As part of strategic planning, Sustainability focuses on ecological and spatial impacts, the latter divided into supply (consumption of water, energy, fuels, and sanitation (solid

waste, wastewater, toxic gases). It also considers aspects of the problem, both scientific and ethical and, at the same time, considers the limits and maximum possible requirements to maintain the standard of living and economic development (Martínez and Rivera, 2018).

Sustainable Development is an alternative principle to generate a balance between economic growth, social justice and the environment, therefore, it means that there are necessary programs in which the inclusion of human habits tends to the equity of consumerism and creation of services and opportunities, and more efficient production and operation processes that take advantage of the use of renewable resources (Martínez and Rivera, 2018).

Regarding the second element, the Sustainable Development efforts that have led governments around the world to come together to face economic, social and environmental challenges are considered. As a result, they have proposed 17 Sustainable Development Goals (SDG), which emerge within the framework of a United Nations Congress and are proposed in the Agenda 2030.

The SDGs selected based on their direct implementation in practices that benefit the environment are: (1) industry, innovation and infrastructure (2) sustainable cities and communities (3) responsible production and consumption and, (4) Life of terrestrial ecosystems. These objectives were considered in this research, in which they become the main axis of the study and are called Sustainable Principles.

The companies of the mining sector, like the rest of the industries, are attached to the regulations, which are described for evaluation and monitoring in the country's legislation; these became the third element of the study. The regulatory analysis takes the environmental aspect to mitigate the impacts, that is why companies in the metallic mining sector must describe the impact risks in official reports.

On this basis, the agencies that belong to the government sector evaluate its veracity in the document: Environmental Impact Manifest (EIM). This report describes 109 parameters, of which 16 have been selected to carry out this investigation. The description of each one of the 16 Legislative Parameters represents the link by which they are directly related to the Sustainable Principles.

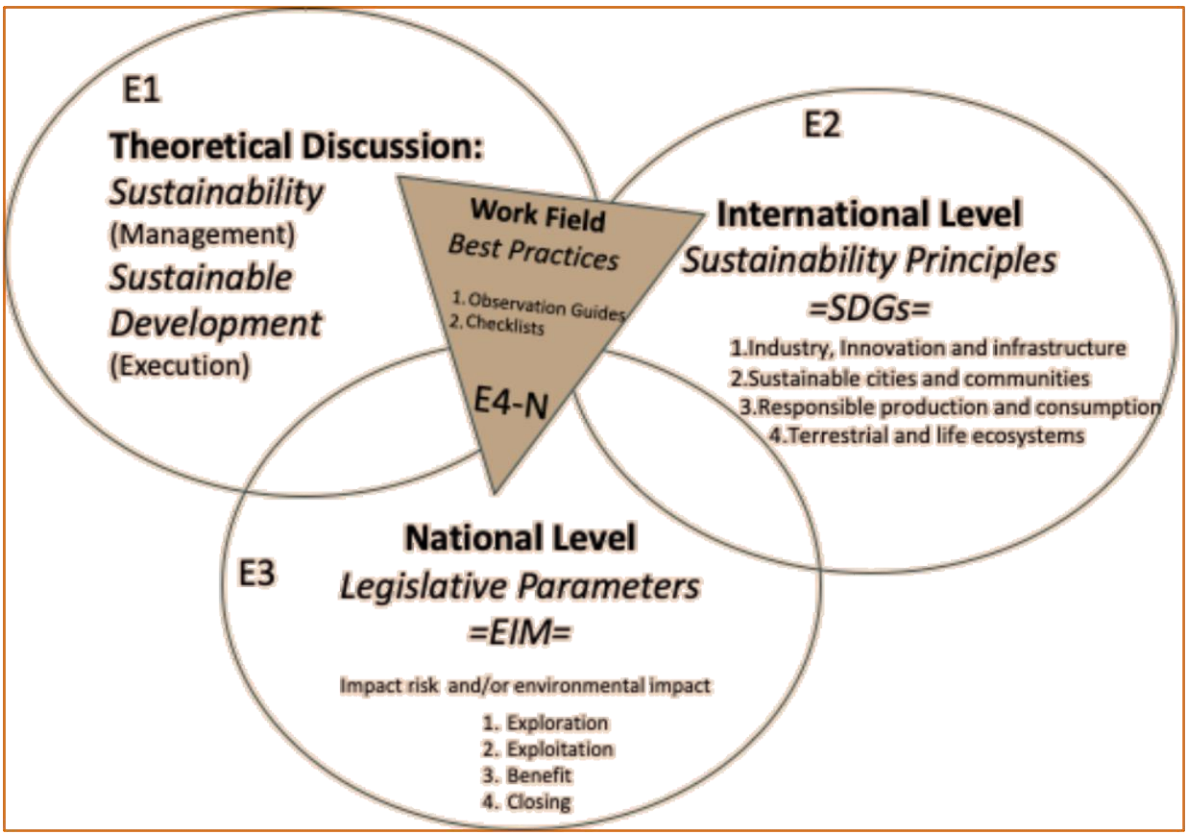
The fourth element represents an innovation to traditional models, which are theoretically supported; this element, in its execution, achieves the real way of obtaining information about environmental practices, evaluated from the literary foundation.

For this, the methodology used in this field work was based on a Case Study (Yin, 2013), which allowed in one of its modalities -Simple Holistic Case Study- to select a unit of analysis for convenience (Hernández, 2014), a unit belonging to the mining-metal sector as a representative sample.

3.2 Sustainable Management Model for the Mining-metallic Industry - Figure

The structure that the proposed Sustainable Model acquires is shown in the following diagram. The foundation required to arrive at the fourth and new element (E4-N) is mentioned in the first three elements (E1, E2 and E3), which is expressed as added value by this research.

Figure 23**:** Sustainable Management Model and its elements for the Mining-metallic Industry



Source: Own Elaboration.

3.3 Codification of the Sustainable Management Model

3.3.1 E1, element 1

It represents the literary link of concepts of Sustainability and Sustainable Development and, based on a theoretical discussion, allows the research to present its own way of expressing them through Environmental Management.

1.3.2 E2, element 2

It refers to the second element, which involves the theoretical basis that provides the main axis of the research: Universal Principles of Sustainability.

1.3.3 E3, element 3

It refers to the third element, this is the theoretical basis that the Law in Mexico brings to companies in the mining sector, obligations measured in Legislative Parameters.

1.3.4 E4-N, element 4, new (added value)

The fourth and new element is presented as the first collaboration of this research as an added value. It contains the field work that also included the construction of data collection instruments (Observation guide and checklist).

4. Importance of the Sustainable Management Model for the Mining-metallic Industry in Mexico

The Sustainable Model for the Metallic Mining Industry, was built to be integrated into the strategic planning of the companies that make up the country's mining-metal sector, in order to eradicate or reduce negative impacts on the environment.

In order to carry out a comprehensive investigation, which would allow the creation of a Sustainable Model that is implemented within the Environmental Management of companies in the mining-metal sector of Mexico and through it obtaining improvements in environmental practices, it was required the approach to literary foundations and field work that would allow unifying sustainable principles suggested by international organizations and parameters required by Mexican legislation.

It is made up of theoretical-practical bases, which in the first instance led to the creation of data collection instruments, subsequently applied in the unit of analysis, that is, mining-metal company: silver, Mexican, which formalizes a Simple Holistic Case Study method.

These bases have been the result of the literary contextualization and the support of the field work of the measurement of impacts and / or risks of environmental impact observed through international sustainability principles and parameters that the country's legislation requires and jointly, they form the elements that give structure to the Sustainable Model. The four structural elements are characterized as a complement to the Sustainable Model, based on the foundation detailed in the Chapter II of this research work.

4.1 Theoretical utility

The Sustainable Management Model presented, allows the Management staff, to assess how the strategic plans of their organization, comply with the social, technical and environmental responsibility that with respect to the Sustainability and international public policies have become a priority for the countries in terms of effective activities focused on the remediation, preservation or conservation of ecosystems; likewise how these activities provide the safety of operation through compliance with the regulations that the various Secretariats of the Public Function of Mexico require of each mining unit. It is considered the element 1, theoretical discussion, representative of this postulate.

4.2 Practical utility

Based on the construction of element 2 that describes the Universal Principles of Sustainability, the Management Model delimits its sustainability construct based on the attention that Mexico's metallic mining companies have on international suggestions (UN, 2016) through the observation of four Sustainable Development Goals described in the 2030 Agenda. The purpose of this element is to verify how the daily activities that are carried out according to the environment, align and contribute to international public policy.

For its part, element 3, represented by Legislative Parameters, in the implementation of the Sustainable Management Model verifies compliance with the Environmental Impact Manifest in terms of its official provisions, for this, a disaggregation is carried out that focuses on mining operations that are directly related to activities that in its execution create risks of environmental impact.

With reference to element 4, the environmental practices carried out in the metallic units are considered as the starting point of the observation of the Universal Principles and the verification of compliance with the Legislative Parameters, in such a way that allows those that in their execution, are really effective and remedied, to be extracted, minimize or eradicate the risk of environmental impact.

4.3 Theoretical Utility and Methodological Value

As a hole, the Sustainable Management Model presents Theoretical Utility from where different concepts arise as Environmental Management from a more updated perspective, and also presents, Methodological Value by presenting the possibility of being replicated in any company of the metallic sector of San Luis Potosi and the country, and even in the entire Mining-metallurgical Industry: exploration, operation in open pit and underground mines, units in the closing stage and Refineries.

4.4 Scope of Results

In this sense, the intention of the study is the replication of the Sustainable Management Model, so that in addition to pointing out these effective environmental activities or tasks, there are comparisons between the total units of the metal sector of San Luis Potosí and even extend it to the country to base best practices; it should be mentioned that the model is comprehensive of the regulations at the national level, so there is also the possibility of replicating it throughout the Metallurgical Mining Industry of Mexico, thus providing future theoretical and practical research aspects.

Reflection

The intention of this chapter was to show the methodological process carried out during this research from its theoretical-conceptual foundations so that the reader has a clear vision of what has been done. It is a methodological justification that explains in detail from the preoperative stages to the interpretation of the findings and that results in the proposal of a Sustainable Management Model for that can be applied in any company in the Mexican mining-metallurgical sector.

Of course, this theoretical-methodological model has implications that go directly in the Environmental Management and environmental practices of workers in this sector, whose labor participation affects not only mining work spaces, but in the communities surrounding the location of mining units, which places them as co-responsible to mitigate damage to ecosystems and seek minimal environmental invasion by the activities they carry out that while it is true, contribute to national GDPs, that can not ignore their responsibility to future generations.

The Simple Case Study of a holistic type described in the following chapters corresponds to a carefully designed sample selection designed by the researcher since its representativeness in the mining-metal sector is relevant in terms of mining methodology but also by the economic implications it has. Facts that were decisive for the application of data collection instruments designed for this purpose.

Present a Sustainable Management Model, allows the researcher to perform stages of implementation and validation of the same in a selected metallic-mining unit with methodological rigor, thus allowing to present to the reader, details of construction of the instruments of data collection, construction, implementation and validation of the Model and, results that obey the initial approach of the study.

CHAPTER VI. CASE STUDY IN UNDERGROUND METALLIC MINE: DESCRIPTION OF RESULTS

PRESENTATION

This chapter presents the Case Study respecting the descriptions that from the data collection using the correspondent instruments that were created for this research, are recorded after the planned visits and programs with the analysis unit: underground mine. A structure for presenting the case was standardized, obeying the foundation of the method, in addition to aligning it with the specific objectives of the investigation.

The first section is made up of a special introduction to the unit. A pre-operative diagnosis was made to the investigation, which is formalized in a technical report prepared in conjunction with the mining expert, after the first field visits. This report includes comments on the technical situation and how it affects the environment.

The next section contemplates the Case Study. In it, the description of the problem that frames the unit of analysis is presented to provide vocabulary and knowledge of the particular foundation, the context of the unit, which geographically and temporally locates the reader; the particular problem that characterizes the unit and the general information of the unit. It also includes a review of how the researcher was immersed in the unit through field work. The descriptions are presented as results and are written for each of the Sustainable Principles, emphatically considering the legislative parameters in each section.

The last point described in the case presents the particular conclusions, which express the perception of the researcher in a timely manner in the face of what was observed and recorded with the data collection instruments used, in addition to the interviews that were presented in an informal way with the middle-high managers and the guidance of those responsible for the environment of the analyzed units.

1 Case Study: Metallic Underground Mine

1.1 Analyzed Unit MSJ, Metallic Underground Mine

Once the Management of the MSJ mining unit accepts the invitation to be part of the descriptive research for the implementation of a Sustainable Model for the Metal Mining Industry of Mexico, they are included in addition to a particular program of individual and joint activities, guided tours for data collection and the possible opportunity to take some photographs as evidence. Under reliability formats, access to the unit was open to the researcher and to a mining expert who would accompany these visits as a guarantee in the technical aspect.

When the first field data were obtained, an arduous desk work between the expert and the researcher was carried out for the correct description of the events observed in the mine and in the offices with those in charge of the environment and safety department. These visits were solely for reconnaissance.

Based on this recognition, a technical documentary report was made, in which particular observations were recovered regarding the impacts or risks of environmental impact that are known from experience.

The presentation that was generated for this report was respected in its original format, which is why it is found as Annex 5. The modifications that it suffered were: name of the unit, corporate, and personal names (these were omitted completely) , specific towns, these points being requested by the management and as a condition to carry out the study in their facilities, under the legal protection of confidentiality.

Once the diagnosis is made and documented in a Technical Report format, the researcher accesses the mining unit and is guided by the person in charge of environmental aspects and, based on the data collection instruments, begins the information gathering, which is subject to the proposed Sustainable Model. These visits were repeated a couple of times more, to correct some points of doubt and to collect documentary evidence, classified as unobservable and which is recorded in the Checklists. It should be mentioned that the time when the study began (from the request to the results stage), there were two environmental managers and two

General Managers, so obtaining information was complex when having to communicate what was previously documented, to the new managers.

1.2 Description of the problem

The mining activity has contributed to the founding, establishment and economic growth of Potosí regions, so from being an activity that generates an economy at the beginning, it spreads and manages to incorporate several dimensions: political, social, cultural, and environmental (Sánchez, 2014).

Foreign investment in this industry has not been long in coming into the country and in the state of San Luis Potosí; the unit of analysis, subject of study, has been in charge of several transnational mining companies acquiring the rights to exploit it, starting decades ago, in an excessive way due to the lack of legal limits, extracting the mineral resource in an irrational way, obtaining from this, high economic benefit and leaving in its wake, social discontent due to environmental impact (Sánchez, 2014).

The mining legislation in Mexico in its execution and description is widely contained in legal systems, it presents contradictions and there is a notorious lack of mechanisms to monitor effective compliance. Throughout history, socio-economic difficulties, political disputes and external pressures have prepared information that has generated that the regulations on mining activity have been constantly exceeded and attacked (Sánchez, 2014).

Mineral resources are not renewed, for which mining is an activity that must strive to operate responsibly to achieve the best use in the extraction of the resource and obtain the expected economic benefit without this being at the cost of social, legal or environmental impacts.

The methods to extract the mineral are usually generalized in two: open pit and underground. The exploitation of underground mining deposits is used when there is sterile material surrounding or covering the mineral sought, that is, there is more material without value than with economic value, in addition, it is found at a high or medium depth, being most of the time the case of metallic minerals. The difficulty of grinding or separating the minerals in situ makes it impossible to exploit them through

an open pit mine project, which, due to the lower cost involved, is always the first option (Jiménez and Molina, 2006).

Designing an underground mine begins with the spatial division of the deposit, with the inclusion of a myriad of studies about levels, fronts to exploit, arrangement of work underground, location and behavior of veins[16], among many others, regardless of the form to be carried out, that is, the method of exploitation. This design is also determined by the size and shape of the mining site, from the results of the deposit studies in terms of quantity, shape, pressure, type of rock, sterile material, mineral quality, among others (Jiménez and Molina, 2006).

The underground exploitation pursues the mineralized zone, which is usually narrow and deep, following technical and economic evaluations, the investment in the drilling of tunnels, ramps, slopes, tunnels, mining shafts, is guaranteed to enable extraction (EMDELP SAC, 2016). Like any industrial process, the design of an underground mine has its own phases, among which there are three main ones: (1) Development, tasks that facilitate access to the deposit, (2) Preparation, division of the deposit into blocks, seeking that they are regular in shape and, (3) Exploitation (mining operation), work tasks to knock down and extract the mineral (Jiménez and Molina, 2006).

The economic considerations that must be made are concentrated on the extraction of a considerable percentage of the deposit to make it profitable, since each stage in the design of a mine, underground or open pit (in much lesser proportion), involves a strong investment. Normally, the economic affairs of a mining project are usually solved through foreign investment, search for partners, bank financing, agreements and, to a much lesser extent, own resources.

Another considerable point in the design of an underground mine is the environmental impact generated, the exploitation system necessarily involves the use of explosives. This part of the process is known as blasting, and it uses an endless number of systems with different types depending on the design of the mine and the conditions of the mineral to be exploited (EMDELP SAC, 2016).

[16] Vein, tabular geological structure that contains minerals in different concentration and quality (Martínez, R. and Martínez, R.E., 2015)

In order to carry out blasting, you must have authorizations from the relevant authorities, it should be clarified that the legislation promotes that authorizations for a mining project are created through the Ministry of Economy (SE) and attached organizations such as the Federal Attorney for Protection of the Environment (PROFEPA), however, the use of explosives falls entirely under the management of the Secretariat of National Defense (SEDENA).

1.3 Contextualization of the Analysis Unit

Mexico is distinguished among other mineral producers, for having great richness and diversity of metallic and non-metallic minerals. The metallic trend[17]s were defined by the classification of the deposits, the underground mine analysis unit, belongs to the Ag-Au-Pb-Zn mineralization trend. (SGM, 2017). 22 municipalities that cover 8 states of the republic belong to this trend: Sonora, Chihuahua, Guerrero, Durango, San Luis Potosí, Oaxaca, Baja California and Zacatecas, in which historically there has been a mining boom since the time of the conquest (FUNDAR, 2017).

The unit of analysis is located in this trend in the part that runs through the state of San Luis Potosí and Zacatecas; San Luis Potosí is a state that has arid and semi-arid areas, and has a landscape characterized by rocks, deep canyons, mountains and plains, this fact coupled with the fact that it is a state that contains, in more than 90% of its extension, metallic mineral and non-metallic. When faced with metallic minerals, due to their location, it favors their exploitation by means of underground mines (SGM, 2018).

The unit of analysis is part of the ASI corporate, of Canadian origin, it is an underground mine, which extracts silver ore (Ag) as the main metallic concentrate and lead (Pb), as a secondary one. The overall design of the underground mine allows ore to be mined after blast cuts and other works are done, the ore is removed and subsequently filled with sterile material. The beneficiation process is carried out

[17] Trend, *alignment of metallic structures as vertical stripes that cross the Mexican republic (Martínez, R., and Martínez, R.E., 2015)*

in the plant that the unit builds for the separation of silver and lead ore from others, through grinding, qualification and flotation (SE, 2019).

The contribution of silver mineral from the analysis unit to the country is very important, Mexico is the first producer of this metal worldwide, according to the Mineral Commodity Summaries (2017); San Luis Potosí participates with 3.3% of the national metal production.

Silver as a metallic mineral, is soft, is used in the manufacture of coins, ornaments, jewelry; in the electrical, dental, battery, ceramic paint, welding, glass, photography industries, among many others (Nordberg, 1998).

1.4 Particular problems

The MSJ underground mine presents a typical mine design, where by means of explosives, you can get to the veins that contain minerals with high economic value, which are amalgamated with other minerals of lower value and with a lot of sterile material, so the extraction from the interior of the mine is enough, in addition to having prepared, or "developed" large extensions to reach the vein (tunnels, shafts, ramps, tunnels), tons of material are removed, which must be processed, or benefited, to obtain just kilos of metal.

To extract the metallic mineral, the vein of the rock that supports it must first be knocked down and paths should be made to be able to reach it, this are important fall of the ore (¨tumbe¨) activities that are carried out through the use of explosives.

Many authors demonize this blasting activity, since they argue that it is a dynamic of resource extraction which is made up of fragile landscapes subjected to environmental disturbance and the destruction of the way of life in order to accumulate benefited material for other industries (Muradian & Alier 2002; Bebbington 2009; Downey, Bonds & Clark 2010).

Some other authors describe events about waste, and how mining generates a great damage to the environment, especially to water resources, which are the support of the people living in regions surrounding mining areas (Bridge 2004b; Bebbington & Williams 2008; Bebbington & Bury 2009).

In MSJ, a problem regarding mining is chanalized. It is an underground mine with narrow accesses, medium ventilation and notable water leaks. The staff turnover indicator is very high at all levels, which has caused the different administrations not to carry out important projects in an operational, social and especially environmental function.

1.5 General information about the Unit of Analysis

The underground metal mine, the analysis unit of this Case Study, is located in the state of San Luis Potosí in border with the state of Zacatecas, it belongs to a municipal head that has a population of 21,398 inhabitants, the mining concessions amount to 1,500 hectares, which have been exploited since 1760 with small mining works under the supervision of landowners.

The operating permits for mining activities or mining estates belonged to individuals until 1890, when they were acquired by Mexican mining groups strengthened between 1948 and 1995, which intervene in exploration with advanced technology and also invest in mining work; At this time, problems arose from the so-called “Non-governmental Organizations (NGO's)” headed by peasants from the area, which led the group to abandon the operation. Re-initiates activities in 1995 (Martínez, 2000).

Since 2016 the unit has been exploited and benefited by a corporation with Canadian capital, who also set up adequate infrastructure for extraction, which comes from other nearby mines. The transfer of this infrastructure was simultaneous to exploration, which generated a potential territorial expansion of exploitation. m^3

It is an underground mine, located in the Ag-Au-Pb-Zn metallic trend, it maintains an exploitation system in sublevels with long drilling, taking advantage of the characteristics of the reservoir's power. Extraction is carried out with a conventional 8 and 12 m^3 truck, which suggests spacious routes within the mine.

The benefit system is the flotation system, generating waste that is thrown into a tailings dam located on three sides of the hill adjacent to the unit. The staff amounts to 200 employees, between direct and indirect contracts. The *usefull lifetime* has a projected production calculation for the year 2021.

1.6 Immersion in the context of the Metallic Underground Mine

Under the methodology planned in a systematic way, it is carried out from the request to the Management, until the completion of the integration of the observations; It was emphasized that it was essential that a person from the unit, with sufficient authority, accompany the researcher in the field work, which included visits to the unit for recognition and the application of data collection instruments: observable guides, checklists (of unobservable data), which were designed exclusively for research and endorsed and validated by experts in environmental mining, as well as informal interviews of the complementary type of information.

Personnel rotation frequently falls to senior managers in this unit, at the bottom of this investigation, it was three different people who were in charge of the safety, hygiene and environment department, and the investigation began with a person in general management and at the time of integrating the information with the other case studies, there was a different person.

The results of the Case Study of the analysis unit, underground metal mine, are presented, which are obtained, after field work, the articulation of the elements (Sustainable Principles and Legislative Parameters) under the described theoretical foundation of Sustainability adhered to Management Environmental.

From the theory, and based on the data collection instruments, the tours of the unit are started and at the end of the unit, some items are specified in terms of doubts and suggestions, in addition to resorting to the evidence that is has, most of this, revolves around the manifests, EIM, which are not shown in their entirety for confidentiality reasons.

1.7 Preliminary description of the results

Based on this information, once recorded in the appropriate formats, it is extracted as a description only without interpreting or evaluating, considering alternative and particular results, which were reviewed with the experts once the information from the analysis unit was collected.

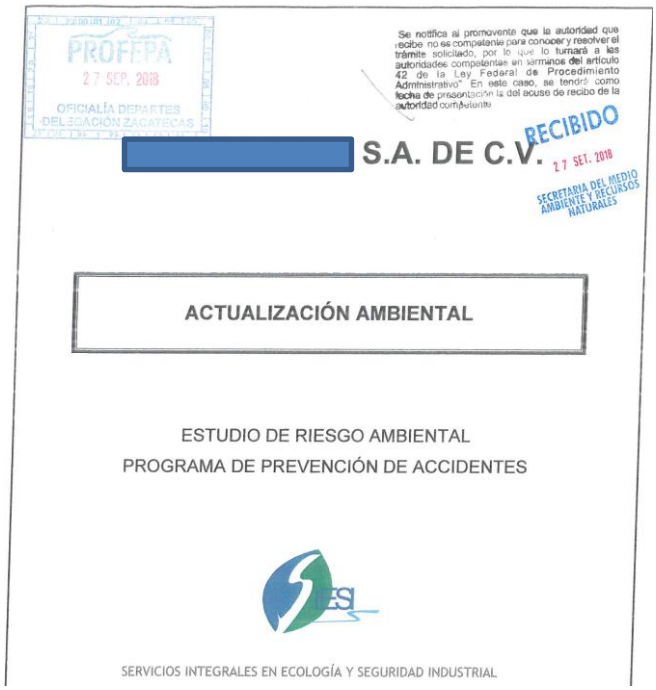
1.7.1 Industry, Innovation and infraestructure:

Currently, no surface exploration activities are being carried out, the drilling sheets opened were not made on forest lands. It depends on subcontracted companies who are required to maintain the equipment in optimal conditions; In the unit, each workshop has concrete plates to carry it out and there is a catchment pit for the hazardous waste that is temporarily stored, as dictated by the procedure they have for this activity.

The formation of dumps of sterile material are located in unprotected areas. There is a tailings dam, and there is even a project not yet evaluated to expand it. The waste from the beneficiation plant is transferred to this dam by means of high-density polyethylene pipe, its discharge is carried out by means of hydrocyclones with thermo-fused couplings to avoid risks of leakage. The design of the dam, which is of the conventional type, allows the material removed from the basin to be used as loan material for the construction of the borders, thus avoiding additional site impacts.

The environmental impact studies are in order according to records of delivery, monitoring and evaluation of the corresponding authority. In the event of unmeasured environmental impacts, an emergency plan is also endorsed by experts and the company's technical manager, for which they also have a trained crew.

Figure 23. Updaiting of environmentals reports



Source: Supplied by the analysis unit MSJ.

Figure 24. Industrial waste collection pits.

Source: Supplied by the analysis unit MSJ.

As evidence, the above figures are shown, to support the provided description of what is observed in field visits to the analysis unit.

1.7.2 Sustainable Cities and Communities:

Historically, the analysis unit has been the subject of social problems, led by peasants in the area, demanding damage for detonations in some places in the village. This has led to operational consequences, one of which has led to the location and design of powder mills, which are assessed with emphasis by the authorities (SEDENA).

Basically, this item minimizes it to social responsibility programs through the Department of Community Relations, which, from a scheduled budget, supports requests for the surrounding localities, thus expressing the inconvenience of the communities argument, that there are differences between what has been requested and what is offered, happening this frequently.

Figure 25. Rehabilitation support to church of surrounding community.

Source: Supplied by the analysis unit MSJ.

1.7.3 Responsible Production and Consumption:

The Productivity of the unit is measured based on the production of extracted mineral: mineralized mineral and sterile matter, in relation to the supply used for it. The mineralized material is sent to the beneficiation plant, while the sterile material is sent to the dumps.

Inside the mine, ventilation is being reinforced, since they are currently serving design and location projects for personnel rescue shelters and work on roads or emergency

exits (ramps, counter-wells). The use of water and chemical solution neutralizers in leaching patios, processing plants and even in the mine, are vast; some social problems originate from this data, since they have been sued for contamination of groundwater tables in the past years.

They have a pumping system, where the water used inside the mine is reused on the surface, since it does not have indicators outside the permitted limits of chemical compound. Regarding air quality, there is no gas monitoring at sites of installation of in-mine extractors, as well as no automated reagent dispensers, so it is performed manually by employees. The waste is transported to the tailings dam with the help of hydrocyclones.

Figure 26. Squad evaluating “Counter-well” project. Inside mine.

Source: Supplied by the analysis unit MSJ.

1.7.4 Terrestrial Ecosystem Life:

Currently, the unit's life projection extends until 2021. Its abandonment project is planned and described in the “Environmental Impact Manifesto” authorized by the relevant agencies. Topics such as hydrology (surface and underground), atmosphere (air and noise), soil, flora and fauna, socio-economic environment and landscape are considered.

The sterile material packed in the dumps will be used to fill works from which mineral was extracted. The total facilities are expected to be dismantled; In addition, there are documents that support devastation studies so that it is measured in risk and

remedied at the time of closure, the tailings dam is also considered, which on its edges is being reforested. The document poorly describes how this dam and its contents will be remedied.

They have financial items for the prevention and remediation of abandonment of each project that has been developed from the current administration. The closure of operations will not take place in the short term, however, communication channels are kept open with the inhabitants about types of mining (explosions), closures and progress of mining works (mine).

Figure 27. Existing studies related to devastation.

Source: Supplied by the analysis unit MSJ.

Figure 28. Care with species from the area.

Source: Supplied by the analysis unit MSJ.

1.8 Particular Conclusions of the Metallic Underground Mine Case Study

This unit of analysis is representative of the Mining-Metallic Industry, since it is an underground mine, the typical mine, of metallic mineral, which are widely recognized for their physical form and, for the product obtained from these. They are metals of value to humanity, as well as for their application in daily life, such as silver, a metal that we easily find in jewelry and ornaments of very ancient civilizations, as well as its industrial use.

The field work of this case study is decisive in the investigation, Mexico is the first producer of silver worldwide, which means that this unit actively participates in the contribution of the metal to economic indicators both in the state of San Luis Potosí, as of the country.

The unit has Canadian capital, which leads it to maintain high standard operating systems, since this type of investor normally trades on the stock exchange. For Mexico, it also represents stability in the sector by balancing investment against what is exported as concentrated mineral.

In particular, the general perception lies in the observations of compliance with the regulations, however, the interpretation in accordance with sustainable principles is complex, because regardless of the fact that it is a medium underground mining unit, certain labor instability is denoted in employees, in the image of office facilities, plant and even the mine itself.

Regarding the follow-up of the case, there was an important pause due to the change of Manager, with whom it was necessary to speak in terms of starting the process, however, once the information that had been available up to that moment was jointly reviewed, he agreed to continue with the study, allowing access to the unit and although more limited than at the beginning, access to documentary information; This makes more evident the problem of staff rotation that they have within the departments and therefore, the lack of communication and, failures in the continuity and follow-up of the innovation proposals.

2 General integration of the Observations of Sustainable Principles and Legislative Parameters

To reach the desired result, a first relationship of the production process (in stages as a first phase, then global for presentation purposes) was made to the principles, following the goals pursued by these persecuted. This relationship is made considering as a dependent effect, the impacts and risks of environmental impacts arising from industrial process activities, described in Chapter V, in which the relationships found are described.

Each Sustainable Principle considered in this research individually is presented in four sections, describing, from the field observations, the Legislative Parameters selected and related since the drafting of the productive stages in the mining-metallic process.

This point is divided into two parts, the first is the graphical display relationship of these elements and the second is the description detailed above.

2.1 Leopold's Matrix: Sustainable Principles, Legislative Parameters, Productive Stages of the Mining-Metallic Industry.

Once the result, derived from a tripartite relationship of the key elements of the research and the productive stage of the mining-metallic sector studied as described by the General Coordination of Mining (2014), prepares to present the subsequent interpretation of each Sustainable Principle in an orderly and easy-to-understand manner.

It is presented for this purpose, a Leopold´s matrix, used to relate several inputs of elements of equal importance and logical reading to the fundamentals presented prior to their formation or registration. It is a format in which encoded information is placed to store data in a compact way without detract from its place of care.

Table 18. *Sustainable Principles, Legislative Parameters, Productive Stages of the Mining-Metallic Industry*

	Industria, innovación e infraestructura				Comunidades y ciudades sostenibles				Producción y consumo responsable				Vida de ecosistemas terrestres			
	Explor	Explot	Benefi	Cierre	Explor	Explot	Benefi	Cierre	Explor	Explot	Benefi	Cierre	Explor	Explot	Benefi	Cierre
Tiempo de vida útil					x											
Responsable técnico				x				x				x				x
Naturaleza del proyecto		x								x	x	x		x	x	
Dimensiones		x		x		x	x	x		x	x	x			x	x
Uso de suelo	x	x	x	x	x	x	x	x		x		x	x	x	x	x
Urbanización del área	x	x	x	x		x		x		x	x	x		x	x	x
Preparación del sitio	x				x						x	x				x
Construcción de obras		x	x					x		x	x	x	x	x	x	
Operación y mantenimiento		x	x	x	x			x		x	x	x		x	x	x
Abandono				x				x				x				x
Uso de Explosivos		x				x				x				x		
Gener-manejo residuos		x	x	x		x	x	x		x	x	x		x	x	x
Infraestructura de manejo residuos				x				x			x	x			x	x
Aspectos abióticos					x			x		x	x			x		x
Aspectos bióticos					x			x								
Paisaje		x	x	x		x	x	x				x		x	x	x

Source: Own preparation

3 Interpretation by Sustainable Principles: results

This section can be considered, within the results, as one of the main ones. It is the basis of the validation of the Sustainable Management Model, since through an element of the practical or operational type (E4-N), which involves fieldwork in the analysis unit of the Simple Holistic Case Study, the integration of the fundamentals described for the formalization of the model in elements E1, E2 and E3 is justified.

The following descriptions correspond to the focus of the research: Sustainable Principles, involving the researcher's observations, advice on review and interpretation of information by experts and, solvency of doubts with the staff of the analysis unit, all in relation to the Legislative Parameters that are implemented under the format of strategies, programs, techniques, tasks.

3.1 Industry, Innovation and Infrastructure

According to the *Agenda 2030*, there is a shared responsibility, in which countries, companies, organizations of all kinds and the people themselves, must promote development from their environment, with the tools and capacities available, that is, the capacity of a developed country, is far from those undeveloped countries (Viota, 2017).

This aspect is reflected in the mining-metallic unit analyzed. The general perception of complying with the responsibility imposed by the legislation and by the very criterion of care towards the environment, is most often expressed in the areas that belong to the administrative part, that serve the indications of the corporate and, through its process is provided, in addition to its final product, elements to strengthen the economy of the company, the region, the state and therefore the country.

The infrastructure of the analysis unit is very complex, has established, adequate and functional offices for staff; their departments and staff roles are clearly defined, even though the unit has fired, rotated or suffered resignations with high frequency at all operational levels.

They have minor and major maintenance workshops -*waste generation and management* - and these are spacious, have the necessary tools as well as qualified personnel, maintain adequate registration controls and also have a documented procedure of rigorous work schemes -*hazardous waste management.* The analysis unit can be classified as median, and although it has these maintenance platforms, the perception is that they are of low quality, because their size and general appearance are not of order and cleanliness, which can result, despite having plates and channels of waste collection as well as temporary warehouses for this item, in soil contamination by oil spills or other types of chemicals, such as lubricants and even reagents of the mineral benefit process, when it is the case of warehouses. It is a unit that usually outsources, most of the maintenance is carried out by external personnel, because not all the equipment is own, but leasing and the company that provides this service, provides the qualified personnel for the task.

The *dimension* of the project is medium-sized in territory in addition to covering *by* the *project nature*, two villages; the advantage is that they are not important urban

areas, however, they have been monitored by so-called NGO-s groups. The devastation observed is limited, it is an arid and valley-shaped area, allowing to avoid remarkable damage or disorder; there is timely evidence of formality and awareness with the *biotic and abiotic aspects* (flora and fauna) as well as with the *landscape* itself, elements that seem not to be flagrantly affected at the time of *abandonment.*

The *constructions of work,* carry out, become obligatory; both for employees and for the inhabitants of the surrounding areas has become a imposed role since they do not adopt the commitment to financially support the construction or improvement of hospitals, schools and especially roads and roads, but under the perception of informants, they are covered by these actions, the damage caused by vibration of explosives.

The unit has not contributed much to the infrastructure of the villages, they do not provide drinking water and the access routes have still stretches of terrace, being that to reach the unit you have to cross them; mine staff are ready to assist in various works of the company-backed community.

In terms of innovation, the monetary factor is noted, equipment and operational methods, have adopted over time, improvements that should be reflected productivity, however the technology has adapted from other units and has become only functional. For the benefit of the environment, they have provided improvements to processes and equipment that could emanate liquids or solids into the environment, in addition an important point is the existence of dams, which receive toxic or mineralized residues; this analysis unit, has not arranged re-design and extensions and this is close to the catchment limit. There is monitoring equipment, both for aquifer mantle and atmospheric emissions, which serve the surrounding communities.

The equipment of the analysis unit is old, despite being also of foreign origin, has not been updated, its appearance is dirty and rusty in some cases, in the mine it should be taken into account that it was equipped with balances of other mining units. *Construction of works* is not easily perceived, although they declare commitment to the community.

As part of the industry, within the sector to which it belongs, the analysis unit expresses being aware of Social Responsibility and for this, they have scheduled actions adhered to formal strategic plans that promote within the community and, they place greater emphasis on them through media communication, appearing great actions, the reality is that these tasks and strategies work, but by feeling them directly, they are less shocking than they are perceived in their virtual or printed information.

The *project nature* is a determining element for the sustainable development of the surrounding communities, since it indicates what type of exploitation and profit process, among others, the mining unit will have. Faced with this fact, geotechnical studies, expansion studies, those of tailing dam design, will have a noticeable, not necessarily negative impact on the environment and the way of life of these. Water collection is one of the items that nearby analysis units provide, an important fact about it, is that they build plants to treat wastewater and what is necessary to provide commonly used water, such as extraction of new wells, chemical analysis, forms of channeling, which is used by the community on a permanent basis - *construction of works.*

3.2. Sustainable Cities and Communities

One of the challenges described under the Agenda 2030 is to raise awareness among all countries about how they demonstrate capacity to achieve sustainable development; the survival of societies and systems that are intimately related to biological communities must become imperative tasks. Lacking or poor development of communities can be caused by lack of access to or mis management of natural resources, such as abuse or devastation; due in large part to this fact, environmental degradation has a direct implication in the ability to establish stable and lasting development over time for communities (Viota, 2017).

The development of communities surrounding the analysis units suggests a high degree of influence on their part. This is most noticeable in those that are perceived with greater economic power. The location, close to communities, suggests the support provided, on a permanent basis, although it seems that at the time of dealing with social problems by ecological and environmental arguments, this support increases or starts even in some areas; it is recorded over time, as apart from being

a source of employment for the area, certain activities that support development are promoted, however these are usually requested for damages reflected by the operation of the mine, so they have lost their value.

To this end, mining units are also required to consider exclusive budget items that go beyond their closure plan and day-to-day operation, in view of partial and permanent *abandonment.* Within these activities, they implement "green programs", which are reflected in reforestation of land damaged by mining activities. These activities serve a dual purpose, as they perform tasks visible to the community and improve the *landscape,* reactivate *biotic and abiotic aspects* and, as an added value, educate the new generations, since infants are the main guests to carry them out.

These activities seem distant in the underground mine analysis unit, which despite having descriptions of community support, are far from impacting the *landscape* favorably. The relationship they have with the community, which are further away from the operational zone and especially from the mine area, they promote more actions through conventions, where they seek to have means of communication -*construction of works*- accessible to all, certain supports for fractures to vibration constructions -*use of explosives*-; employment for the communes and even their families in more appropriate tasks, local consumption of fuel, perishables, real estate (rents for non-local employees, visits, suppliers), among others.

Communities develop capacities in their individuals to become independent and sustainable and, in terms of resources, seek to require mining units to support or restore them; often this social aspect, generating sufficient and serious problems, since from the support and awareness of companies, there is a conversion to the obligation that communities feel and begin phases of abuse.

Mexico's migration indicators are often high, inhabitants, especially males of productive ages from the poorest communities, seek to emigrate to provide their families with better opportunities; the villages near the analysis unit, which already suffered temporary closures with other companies, has been devastated by this event, the community has survived with women and children mostly in less productive labor, since their workforce migrates in search of work.

Faced with this event, the suggested strategy is to promote and teach trades, in addition to building the training centers and those in which they will work, so that the inhabitants do not suffer the consequence of losing their jobs and have the option of not emigrating because they can generate self-employment; these intentions regarding the community are not described in the analysis unit.

In view of the closures they have suffered, learning about the strength that the union of a nonconforming society may have and radical groups or NGOs, the corporate group to which it belongs, has developed strategies to cushion opposition events, however they have not described a closure plan and its projection by declaration regarding *land use at the* EIM, is in 2021.

The observations in this Sustainable Principle do not present these conditions, their budget items are not expressed, there is no knowledge of the administration to close them, so provide support suggests to the high administration extra work or contribute it when required and, this effort is usually timely and not starting from a strategy. Their closure plans are uncertain, unknown and seem to only cover activities that are often observed as audits by the authorities. Its general aspect, that is, the perception that this unit has, is to meet the requirements; the unit shows no knowledge of a closing plan. Its appearance *(landscape)* is not of order, especially its underground mine, where ventilation, excess moisture and water creating silky roads, provide a flawed and non-harmonious with the environment and there are latent risks. Their accesses are dirty and their counter-punches or emergency shots are unstable. Staff turnover has led management to hire young apprentices, reflecting this in the fear of making decisions or doing so wrongly, so their activities are perceived to be limited and in-experience, as well as being inflexible.

3.3. Responsible Production and Consumption

Viota (2017), describes about soil damage in relation to water supply, a vital liquid for society; affirms that 80% of wastewater resulting from human activity pollutes rivers and seas in which they are discharged in addition to the overuse of the resource by communities.

This aspect is considered in the Mining-Metallic Industry as a fundamental. Numerous efforts have been made based on wastewater control and strategies to minimize

resource use. However, much remains to be done, the waste dams of the benefit process – *hazardous waste management* - are a reflection of pollution especially to the *landscape,* since the new tailing dams and some middle-aged, have been designed in such a way that they have rubberized membranes in the background and edges that prevent leaks.

The unit of analysis has its own waste dam, in the mining sector they are often referred to as tailings dams. These dams are formed by wastewater used in the process of separating and transforming the minerals sought from others that are in nature and the sludge or sterile material that accompanies them, so they usually have economic values, that is, they still have ore, only in separation, it was expensive to recover them and sneak as waste.

There are major ore recovery projects for dams, and these are an important part of environmental strategies, which require strong investments to be carried out. This economic circumstance, has hindered these activities and therefore the dams continue to fill, there is no recovery of values, the *landscape* is still perceived as polluted and there is no room for reforestation or restoration of it, *biotic and* abiotic *aspects* are not re-installed in areas surrounding the dam.

In addition, there are reason regulations to the so called Mining Environmental Liabilities (MEL), since by history, many tailing dams that by their age did not enter the legislation now imposed and also many within the schemes of small miners, which do not have sufficient capital and environmental aspects seem to be managed not on a par with production, but only as part of compliance to obtain the relevant authorizations to continue operating, that is they conceive of superficial results without actually having made substantial changes in form and results.

The tailing dam in the unit of analysis presents a complex pollution perception situation. They have presented to the relevant authorities, an extension in their dam, which has a design of fortified membranes and edges built with sterile rock that allows vegetation, to contemplate a better image; there has been no success in research for recovery so they have promoted containing in depth and restoring surfaces until reforesting them, the design is own to the ground, which forms a large shell at the

bottom, which helps in addition to artificial membranes, to avoid any filtration to groundwater mantle.

While the resource that for this sector must take the greatest care not to abuse it and to be able to supply and maintain the industry and, continue to enjoy the economic goodness and the creation of most items, large and small that provide comfort and meet the needs of the human being, are the minerals extracted in the various deposits.

The mineral resource is not renewable, its formation in the bowels of the land, dating from hundreds of years, Mexico has numerous and diverse deposits rich in metallic and non-metallic minerals, has a history of founding important cities based on the extraction of these, so to think about stopping the industry, would be counterproductive in the economic format of the country; their populations would also suffer from joblessness and community development. However, expecting the environment to be unaffected by mining operation has proved fictitious.

Minerals are required for different industries, so the capital of foreign companies has been mobilized in the country. Numerous companies, exceling Canadian companies, have managed to get the Mexican government to authorize above all the exploration of deposits, which is the first stage of the mining-metallic process and the less aggressive and invasive, does not affect *landscape* or *abiotic and biotic aspects.*

However, their investment is growing in the extraction of ore, giving strength to the arguments of NGOs to take the exploited ore. Having no reason in this at all, since companies already have their customers, there is no mobilization of the concentrated mineral resource to a defined country, however, as regards the arguments of environmental aspects, it is observed that they do not adequately comply with the legislation, the analysis unit of this research, in the form of an underground metal mine, has foreign capital , has suffered the politicization of the problem with NGOs, denotes natural devastation, and little or no attention to its appearance and image, although they describe activities within the legislation, the perception of these is usually negative.

The only data obtained from the unit of analysis in terms of *usefull lifetime* of the ore comes from the studies of mineral deposits carried out, which are described in the EIM, thus, this unit were projected to 21 years.

This data is generated based on past geological studies, however, current and upcoming exploration will provide more projects on site, close or elsewhere in the territory. Mexico is considered kind in mineralized subsoils, and exploration studies have been confirming this.

The depletion of natural resources, the negative effects of the degradation in the environmental field, are challenges that the Agenda 2030 stipulates as primary matter, so the continuous effort that the Mining-Metalicl Industry has made to do so, is important but not sufficient. Futher applied research is required, not only published, it requires updating equipment, processes and work systems, all depending on targeted investments for the objective. However, it remains the most complicated problem, that human beings, occupying managerial vacancies, owners, investors, members of the corporate, rulers, auditors, villagers and end-users, be more aware of the meaning of natural resources and their current and future benefits, their devastation and exhaustion, to replace and minimize the exploitation that degenerates and ends this in nature.

3.4. Life of Terrestrial Ecosystems

As a challenge to the Agenda 2030, forced displacement of the population is described as threatening to nullify development progress. Firstly, to create and preserve a risk-free, clean and healthy environment that has sustainable characteristics to achieve well-being and guarantees to human beings to enjoy the natural rights that are inherent in them (Viota, 2017).

This Sustainable Principle by its nature, is the one that has the greatest visual and conscious impact. It is one in which everyone observes the affectation of the environment, by devastation and by consumption of the natural resource extracted. With foundations promoted on the basis of this Principle, NGOs and other associations have created anti-mining movements in the country, seriously affecting organizations from their inception to generations, exposing it as a country without

economic development, since it is this spearhead sector for other industries that strengthen Mexico's economy, like the automotive, for exposing some.

As an aspect within the environmental strategies of the unit of analysis and all mining units in the country, it is often commonly interpreted as ecology, and translated into practice as “green programs”, where they convene the community to participate in the reforestation of areas that they have normally already restored, even though these actions are very important and help to release the pressure of society and authorities, they are educational and create awareness in the participants, but they are not enough against all that by extension -*dimension*- the mining units devastate.

Strategies should go beyond the statement they make at EIM, they are responsible for enlisting all the parameters that the country's legislation requires to comply with. For example, plant and animal species- *biotic and abiotic aspects*- that inhabit the zone that will be indirectly devastated or impacted: with vibrations by use of *explosives*, accumulation of mineral waste (tailing dam) -*generation and management of waste*-, construction of large units of work (industrial infrastructure, plants, the mine itself); describes *dimension, useful lifetime*, a *technical responsible*, its form and work design –*project nature*-, but are not very descriptive explaining how they will take care of them and even though they apply the budget items (they mention them), but do not detail them timely application. In general they know the strategy to follow for environmental care, but they are far from having the effective practice to do so; their presence is remarkable near or far from important cities or communities.

The set of parameters is not only responsible for taking care the visible environment, this aspect should be better considered within the main strategies of the mining units; the unit analyzed describes the care practices, but does not denote living them and the real work on conversion and awareness of the people. *Land use,* which is the common way to apply for authorization from the environmental care agency to operate (SEMARNAT), describes the impacts of operating a forest area, for example through an EIM, which provides the information from previous studies on the zone, and the actions they will take to minimize the damage, but the risk continues, there is still devastation and they have not yet repaired in the MEL´s.

Technical Responsible should guide environmental strategies, this parameter to be evaluated, the unit of analysis did not show the evidence that the count with; they justify themselves with the confidentiality clause.

4 Practical validation of the Sustainable Model and best practices of the unit of analysis: results

4.1 Validation of the Sustainable Model at field

Based on the literature, it was possible to establish that for the proposed Sustainable Management Model, it was important to put it into practice to observe whether its functionality could be incorporated into everyday activities and above all adhere to the strategies that start from high administration as part of its Environmental Management.

Building a Sustainable Management Model with foundations on universal concepts such as Sustainability leads research to validate it using a methodology that allows evidence of local practices to be generated and how they are or are not adhered to the search for the guarantee of satisfying generations to come by caring for natural resources today.

Through a Simple Holistic Case Study, it was allowed to analyze a unit belonging to the mining-metallic sector and when performed, the model will be validated in its practical form; the method allows to observe parameters in a standardized way, which gives objectivity to the study, this is done with the approach of four Principles emanating from the literature of Sustainability in its universal management: Sustainable Development Goals.

The experience that results after the application of the method, provides in addition to a new proposal of work within Environmental Management, observations that came directly from the areas and operational personnel and, gives the opportunity to follow up on internal and external evaluations in order to generate or strengthen strategies for the environment, not only comply with regulations that do not promote the guarantee of having sufficient resources for next generations.

After the integration of the results obtained, the Sustainable Management Model is fulfilled; it demonstrates practicality in its format by being able to observe and exposes

the environmental practices that are carried out. It should be noted that the unit´s personnel was careful at some points that the researcher was looking for, they justified themselves with confidentiality criteria, however, before authorities and in the face of internal follow-ups, this item should be more transparent and open entirely to be considered within the strategies to be followed by personnel: direct employee, indirect, supplier, customer, visit.

Participating mining and environmental experts make annotations to the fit of the recorded observations, which gives to the study confidence in the veracity of the obtained data and how it is described in the first instance and then, how it is interpreted as related Legilative Parameters to the axis of each Sustainable Principle.

It also allows, during the detailed description, to verify the importance and use they make of each Legislative Parameter; this is rather considered a confirmation of their effectiveness. During the study, about the EIM, the research found that there is a presentation to the authorities, although it is a document that they remain not visible by concepts of confidentiality, their responses in this regard, confirm its existence and, in this, it is declared who is the *technical responsible*, but is not perceived as an important figure that generates, guides and evaluates the strategies. They do not known this person.

The Model is theoretically and practically validated, attends to international efforts through Sustainability Principles and meets the requirements that the country's Mining Law requires, through observable and evident parameters; it is a model that on its basis, can adhere to the strategic plans of Mexican metallic mining units to strengthen the Environmental Management of them. This model is flexible, its structure allows to measure parameters of any country, in addition that the parameters, can be re-named or replaced by what the legislation applies on different places (countries).

4.2 Best Practices of the Unit of Analysis

Companies and organizations aware of the processes and how they put the environment at risk, make use of their knowledge and the ability of research and technology to counter them; in Mexico, the philosophy of companies by culture that they have adopted through foreign currents, such as ISO, have provided concepts or

tools such as *continuous improvement* (Ministerio de ambiente y medio rural y marino, 2011).

Continuous Improvement positions strategic plans and their executable programs into measurable actions to judge whether there were increased targets imposed; at the environmental level, this is possible, however, in the face of official documents endorsed by official authorities, observations become important and that is what is considered relevant in this investigation, given the importance that society has also expressed.

Best or good practices, attached to legality, are incorporated into environmental policies, promoting impact studies, exploitation of natural resources and use & manipulation of material and waste resources, etc., to mitigate or reduce them in physical and cost. Best practices adhere to Environmental Management Systems to certify their policies through bigger programs, such as ISO or NOM standards (in Mexico).

These best practices are usually related to technology that develops activities more friendly to the environment, emphasizing that Mexico is notably relegated in this area (Martínez and Martínez, 2019).

However, environmental practices should be simple and effective actions, easily adopted by staff and alienated to negative impact reduction; involve actions from corporate levels to those of services, promoting behavior and attitude towards the reduction of risks, limited use of water, energy and natural resources, in this case the exploitation of them, and that improve in addition to productivity, the competitiveness of the company at low cost.

Rescuing the best practices observed in the analysis unit, which are proposed in favor of the environment, creates bases to feed back the strategy that is carried out on the subject. The strategy may also be measured by the Legislative Parameters considered for this investigation; with this, the standardization and flexibility at the same time of these practices, involves aligning with the quality systems that are running in the unit: ISO, NOM's, among other national and / or international certifications of its industrial turn.

4.3 Underground Metallic Mine, Unit of Analysis: MSJ

This point is described in two sections. The first part expresses the best practices observed in visits to the underground mine unit, in order to continue them and serve as a model for other units. The importance of this exercise is based on the reality that is observed and perceived, so that from the awareness of all the personnel directly and indirectly involved, better strategies are developed, which not only obey regulatory guidelines, but manage to be effective actions that can be perceived both, in their area of operation and in the nearby villages as part of their Social Responsibility.

Moreover, the areas of opportunity that considered important or urgent, were described. This is denoted by observable type information and which in themselves do not justify effectiveness or, which also fall to the non-observable ones, when they want to find a described basis to complement the field information.

This Best Practices section follows the Model as part of value added. Although in a descriptive way, it yields results that can be channeled into programs developed on a legal (national) and suggested (international) basis, which could reassess the relationship with NGOs and above all, truly reflect in the environment.

4.3.1. Best practices performed

Leveraging infrastructure without use of nearby mines, is a success, although innovation must be complemented by proper installation and constant preventive maintenance and, not to put aside investment in new-trend research and technology, to ensure both the productivity sought and the one with the most environmentally friendly equipment.

Currently, they are making efforts to integrate a tailing dam expansion project, this project begins with the reinforcement of the current dam, which includes a safety factor degree study to prevent leaks and spills, and the expansion will already have these conditions.

As an added value to this dam project, re-design and new design contemplate reforestation at its edges which will improve the *landscape*. These studies involve

chemical analysis of minerals for possible value recovery, simultaneously yielding toxicity results, which prevents them from taking impact mitigation actions.

The unit of analysis has a water treatment-recycling plant, it is mainly fed water that is extracted from the mine by means of pumps; the use given to water is for maintenance of offices and irrigation of gardens, it is possible to clarify to be a unit that has not paved its location, so the earth-dust, is usually a constant in the operational life.

4.3.2 Areas of Opportunity

The analysis unit, as a general perception, is a very messy mine, which is later interpreted as environmental neglect, observed inside the mine, extreme humidity, narrow roads, a poorly designed shot that does not allow adequate ventilation or effective emergency exits. These aspects may lead to the logical thinking of not having in order the environmental aspects the same and, those of un-calculated production, which could lead to excessive exploitation of the mineral resource, also considering that it belongs to a foreign corporate.

The description of areas of opportunity focuses on observing the obsolescence of the equipment, but slowing down with the innovations they make; it is an unit with its outside very "dry" by the geographical area, but since it is not paved in its access and common areas, it appears to be a dirty unit, on the other hand, the underground mine is very wet, which entails a contradiction that they must control.

There is no clear evidence to the learning of past experiences, in which they stopped operations due to the influence and pressure of NGOs, since they do not suggest best practices to be implemented or documents that support strategies in this subject.

Their workforce is perceived to be inexperienced, leading to a series of decision-making that hinder the proposals of in-house experts (several leaders in management in a short time) and external consultors (treatment of their suppliers is to some extent uncordial), the perception of this area of opportunity is detached from the observation of the high score of the staff turnover productivity indicator, included the purpose of this investigation, because of the person in charge of the environment department was change (three environmental managers in the last two years).

The participation of federal agencies such as SEDENA, for the care of the storage, handling and *use of the explosive* required by the operation at the mining stage, is not effective, suggesting immediate actions by the environmental management and safety of the unit, to avoid serious accidents.

Finally, presenting a high risk to the environment and society, the *useful lifetime* data in the EIM, describes 2021 as the year of validity in the face of the reserves calculated to exploit. The opportunity at the time to develop the EIM update to present during 2020, however both, environmental staff and management, do not know or decide not to share studies that support this document.

It may also be that by the coming date of the end of the EIM, they must be feeding back the *closure plan,* however, when questioning about it, there is no evidence that it exists. In this subject, it was also questioned of the budget items that should support this plan and, the answer is also that they not aware of whether it exist. This point remains completely lacking in evidence.

CONCLUSIONS

About the Results

The results presented in chapter V, in which as the approach indicates, with descriptive format and qualitative approach, is obtained in the fieldwork in an analysis unit in through the scientific method Simple Holistic Case Study (See Chapter I and IV) These results are divided into three stages, which follow the specific objectives and general objective for this research.

It was presented graphically the relationship of Sustainable Principles and Legislative Parameters that have been referred to throughout the chapters of this investigation (Chapter V, 2); the format used was a Leopold matrix to achieve an orderly and easy understanding of the generality of the interpretation made of each Sustainable Principle forward, interpreted in the light of the observations of each Legislative Parameter, which were recorded in the fieldwork of the Case Study carried out. This description is endorsed by mining and environmental experts (Chapter V, 3).

The Chapter V4, describes under the concept of validation how the elements of the Sustainable Management Model are aligned based on field observations to the aspects described in the Sustainable Principles and Legislative Parameters format; the best practices that belong to the element that is presented as the input of value and that serves to amalgam the Sustainable Management Model, in addition to granting methodological robustness to the research. It describes tasks, actions, techniques or strategies of the analysis unit which should not be carried out and those, that may be part of a compendium of practices bound by the goodness and influence they exert toward the environment.

1. General Research Plan Conclusions

The Environment is a fundamental element in human development, its protection responds to one of the pillars of the 2030 Agenda, being one of the axes that complete the social and economic aspect of development, presenting itself as a necessary cross-cutting element and not as a particular objective or goal (Viota, 2017).

The international community manages and must ensure the implementation of environmental objectives and targets to secure resources for future generations and

enjoy them today, thus promoting the cooperation of countries, regions, private sector agents and citizens, acting in respect of the environment and promoting innovation of technological, intellectual and financial resources that facilitate the environmental sustainability of human activities (Reidhead, 2017).

Viota (2017) describes that the SDGs, as we seek to conserve nature and biodiversity, preserve ecosystems, address the problems of climate change, be accountable for the production, consumption and use of natural resources, it is necessary to achieve this, that civil society be key to influencing the political reforms, denunciations, activism and environmental awareness of each and every community.

While two positions with a different starting approach are pressing, the pursuit of human well-being through the environment is pressing. So in the face of the common strategy of traditional models pursuing to increase economic and social indicators, the environment supports a new modality in which responsibility is shared between nations, communities, diverse organizations and individuals.

It is then presented, as part of a society in which there is an arduous business movement that promotes economic development, but depending on non-renewable natural resource extraction operations, research subject to the scientific method of working in doctoral thesis format, a Sustainable Management Model, applied to the industrial sector that integrates metal mining operations in Mexico , in order to participate in the search to cushion, minimize or eradicate impacts to the environment, as expressed and required by the United Nations (UN), through its Agenda 2030 document, to all countries.

The objective of this research is the proposal of this Sustainable Management Model which allows Mexican metal mining companies, to carry out environmental practices that are managed aligned to universal principles of Sustainability: *Industry, Innovation and Infrastructure, Sustainable Cities and Communities, Responsible Production and* Consumption and, *Life* of Terrestrial *Ecosystems,* and that allow to ensure compliance with Mexican regulations for the benefit of the environment (Chapter II).

To this end, specific objectives are stated about the implementation functionality of a Sustainable Management Model and the validity it has in the operation of the unit

analyzed; following the scientific method, the research questions guide each principle to the search for adherence they have in Environmental Management as a platform to promote practices that provide regularity before the Mexican authorities.

The hypotheses formulated are answered by means of interpretations developed on the basis of observations obtained from the fieldwork planned and programmed for research, in which, through data collection instruments developed on the basis of literature, the axes of the study are channeled and integrated into descriptions based on the Sustainable Principles (Chapter II, 3.6):

A) *Research studies related with the environmental mining practices have focused mainly on the ecological damage, therefore their results are not aligned with the Sustainability Principles in the Metallic Mining Industry of Mexico*. The implementation of the Sustainable Management Model gives the unit of analysis the opportunity to observe in their environmental practices the alignment with the Universal Principles suggested by the UN, so they have the possibility to measure this contribution.

B) *The determination of the environmental procedures aligned with the Sustainability Principles in Mexico shall be made possible through an investigation of the Metallic Mining Industry.* Once the Sustainable Management Model was validated, it is possible to carry out another research studies looking for the replicate in other unit of analysis.

C) *Definition of the best environmental practices entails the implementation of a Model of Sustainable Management and its field validation in the Metallic Mining Industry, particularly the metallic mineral resource in San Luis Potosí (Silver). It is allow to extend a set of recomendation for mexican Metallic Mining Industry.* Through the field work, which allowed the implementation of the Sustainable Management Model, observations of the environmental practices of the analysis unit were documented, allowing to point out those that are effective in the remediation, eradication or minimizing the environmental impact (Chapter V,4), also suggesting a series of considerations for once the Model has been replicated , more and best practices are obtained that once compared and shared, offer a specific and comprehensive guide to make them

effective (See next section of *Recommendations and suggestions for future studies*).

The fieldwork is due to the operational part of the scientific method based on a Holist Simple Case Study with a qualitative and descriptive technical approach, which, by selecting for its own characteristics, subject to convenience (Hernández, 2014), a unit of the metal mining sector (Silver) of underground mine design, complements research for the Doctoral Program by Management Faculty of the University of Social Sciences (SAN).

The results envisaged in the research approach are generated during the operation of field work in which each Sustainable Principle is described in practice through detailed qualitative measurements through Legislative Parameters, which leads once they are integrated, to the validation of the Sustainable Model, which is the result that points to the General Objective by having a formal and validated proposal for the Mining-Metal Industry of Mexico and being able to document recommendations that promote the implementation of this model throughout the country's metal mining sector.

2. Particular plane: elements of investigation

As an added value, which also responds to the first research question in the face of the possibility of relating the theoretical foundations for its practical application, a conceptual triangulation is expressed that integrates the elements of literature considered main in this research; after a discussion of definitions, the following statement is proposed as the conceptual starting point that integrates these elements that provide the solidity of the proposed Sustainable Management Model structure:

> *"Environmental Management supports Sustainability through strategic planning, where* programs that give *openness* and platform *to Sustainable Development are adhered."*

Based on this statement, it is verified that there is a relationship in the Sustainable Foundation and Mexican Mining Legislation: the research is subject to four principles that are considered as pillars of the proposed Sustainable Management Model, which

are strengthened in their measurement, by parameters that Mexican regulation evaluates through government agencies.

The possibility of knowing whether environmental practices are subject to legislation that evaluates them through a metal unit of the mining sector, is confirmed: the selected parameters of Mexican regulations, were observed directly (in the field) and indirectly (through official procedures), during the practical implementation, of the Sustainable Management Model, thus answering, the second research question.

Taking into account the third and fourth research questions, the type of information generated after the implementation of the Sustainable Management Model, is determined according to each Sustainable principle further evaluated and supported by the information obtained from the legislative parameters by crossing between them based on in-depth studies of each; so the information obtained allows to describe technical factors, with quantitative approach that allows to carry out studies and research of the type applied, creating for scientific research purposes, new lines or methodological usefulness (Hernández, 2018).

In the same sense, the information generated according to this research, allows to analyze, interpret and describe the social phenomenon that develops around the global intentions of mitigating environmental damage by each nation (Agenda 2030) and, through a Case Study, it is possible to observe whether a fraction of these SDDs are launched in an analysis unit (mining unit of Mexico's metal sector) , where it is also found that it is possible to extend the implementation of the Sustainable Management Model in mining companies in the metal industry.

Particularly, the Hypotheses raised, based on the implementation of a Sustainable Management Model in the metal mining industry through a representative analysis unit, determine that research allows us to observe the alignment of current environmental practices with Sustainable Principles and how actions that further support this relationship remain, and that all staff are aware of this , so two hypotheses are confirmed: Current environmental research studies in mining field are based on ecological damage and the results still are far from the correct alignment with the Sustainable Principles emanating from the 2030 Agenda; environmental practices in relation to the Sustainable Principles can be determined through scientific

research.

With regard to the hypothesis to define whether best practices can be tested after the implementation of a tool created with normative bases and sustainable foundation, it is confirmed, since both the field and theoretical validation of a Sustainable Management Model when implemented, observed and interpreted, is described as part of a formal document that follows the scientific research method.

The specific objectives set out guided the research towards obtaining a validated Sustainable Management Model to be implemented in a unit of the metal mining sector. Literary analyses were carried out that allowed to obtain practical clarity of concepts in reference to Sustainability, but with a more specific approach that allows the correct application in Mexican organizational culture, that manages to start from the corporation and is lived at all levels.

Developing the Sustainable Management Model, which is based on a specific objective, also allowed to observe environmental practices according to the regulatory parameters that agencies evaluate to allow proper operability; this is done simultaneously by making observations with an approach that allows to verify whether sustainable principles are promoted and there are actions that participate in the goals that are directed according to the environment, directing this effort to the description of those practices that do lead to a correct alignment and rescuing those areas of opportunity observed.

The purpose of this exercise leads to best practices, which allowed to complete the actions proposed by the specific objectives, as well as to grant a sustainable proposal that allows to raise awareness of the guarantee of the metallic mineral resource, for future generations without sacrificing those present.

The Sustainable Management Model is validated and allows with its implementation the achievement of the General Objective of this scientific research study with application in the social sciences, through a methodology that is subject to the research elements that make up the formality of a thesis for obtaining the doctoral degree of the researcher.

3. Main Axis of Research

With regard to sustainable principles, the following are concluded:

- *Sustainable Principle:* ***Industry, Innovation and Infrastructure***

The unit analyzed, denotes in its infrastructure, obsolescence, the physical appearance of its profit plants are generally old, it is noted that the process itself, is with sludge as raw material, since it is the appearance of the material with ore that is extracted from the mine, fluids to separate it, therefore lends itself so that there is corrosion and dirt by the operation itself, however they denote carelessness as an aggregate.

Innovation plays an important role, and is basically applied to improving existing equipment and processes, not the acquisition of new ones. Other countries (Austria, Germany, the United States, China, among others), have innovated in mining equipment, giving the sector more compact, productive and so-called sustainable models, as they promote cleaner and more environmentally friendly processes, even in South America some of these have already been installed; not so in Mexico, where investment in advanced technology equipment seems to be a boldness and not present in operating plans or budget items (Martínez y Martínez, 2019).

The industry element is well carried out, they have adequate facilities, equipment and supplies, their agreements, those documented and those known by custom, are carried out with mutual commitment, the treatment with trade unions is kept in relative control, operability flows without major setbacks; however, there is a continuing observation on the inclusion of financial, technological, technical and therefore environmental aspects to be considered as the industrialization described in the 2030 Agenda.

It is concluded that the *Sustainable Principle, Industry, Innovation and Infrastructure,* is valid in the mining-metal unit analyzed in this research, the hypothesis formulated in this regard, being an industry that has a physical impact on the environment, is confirmed, its image requires both corrective and continuous preventive attention and maintenance, the area of the mine in the analyzed units, presents devastation and therefore the landscape is affected, in this sense, the hypothesis about being the

mining part different from metallurgy in impacts, is also accepted, since as documented, the extraction process is more aggressive.

According to the results, the mining-metallic sector follows the guidelines that international agencies have defined in relation to environmental policy with respect to *Industry, Innovation and Infrastructure,* represented by the modernization and conversion of industries to be sustainable and adopt clean and environmentally sound industrial technologies and processes, however, the effort must be more arduous, it still requires updating, changing equipment and to complement the part of the process, it is noted that the inclusion of applied research is important for the modernization and introduction of new techniques, as in the past it did with its backyard system [sistema de patios], being adopted by the sector worldwide.

- *Sustainable Principle:* ***Sustainable Cities and Communities***

Communities surrounding the analyzed mining-metallic unit do benefit from it. They are usually located in rural areas, so job creation for their people is paramount, they get help for their colonies, parishes, schools, hospitals, recreation centers, it is even very common for units to build these places and support them continuously with their maintenance.

Roads are an indispensable element in this benefit, mining units need to have access to their operational areas, the mine area is usually located in remote areas, often hundreds of kilometers from the profit plant area and administrative offices, the villages themselves are located at considerable distance from the cities. This need is covered by mining units, carrying roads, building bridges, so that their own transport equipment, personnel, suppliers, have safe access and populations are better communicated.

When these events occur, a positive chain reaction is generated, to the populations arrive suppliers, customers, visits, which require accommodation, food, so that the populations can be provided autonomously by satisfying the required services.

The description of the goodness of the operation of units of the mining-metal sector has been described, fulfilling this expected result, depending on the development and progress of the communities; with regard to severity, it is noted that in the face of a

possible closure, there is desolation caused by the emigration of their mostly male young and adult productive adults, so a major turn is required as a commitment of the units not to create such dependence, but to provide tools to the inhabitants. This becomes necessary, since the populations are rural, where there is, as in the rest of the country, scarce resources for education and progress.

It is noted how the 2030 Agenda specifies that the proportion of transport accesses, the increase in urbanization, safeguarding cultural heritage, proportion of green areas, public spaces, economic, social and environmental support, is met, even often there is often abuse by the inhabitants in terms of applications, so reinforcements are required in the established programs and greater communication on compliance.

- *Sustainable Principle:* ***Responsible Production and Consumption***

The Sustainable Principle *of Responsible Production and* Consumption perhaps its the most relevant in terms of environmental impacts; the observations lead to the conclusion, that the operability of a mining-metal unit, which has several stages formed by various production processes, is as follows: in reference to the extraction processes, these are naturally aggressive, obtaining the ore of the earth is an invasion of the ecosystem, flora and fauna must be removed, there are systems that use explosives, which can also cause landslides due to a bad calculation or, by the expansion of vibration waves damage surrounding areas, can even be populated, in the unit analyzed, for this fact, the parish has suffered structural damage, being a factor of severe problems called communal (community).

For their part, metallurgical processes carried out in the profit plant, seem less aggressive to the environment itself, however as every industry has its areas of improvement, such as the use of the energy and water resource, which must be provided in a more natural way, require updating or acquiring new equipment and being included as budget items applicable as soon as possible , as well as the use of chemical reagents and others that speed up and efficiently separate ore with value from others with less value or sterile material.

The emanation of particles into the environment is a situation with greater control, however there are very fine minerals, which when dried fly borrowly and miles away; the big problem of the mining-metal industry is the creation of mining environmental

liabilities (MEL), which are thrown into prey designed especific, however, the general perception, in the absence of several cases of spills, pollution of rivers and other areas, has alarmed society for generations. In this regard many efforts have arisen, with positive effects, but the damage previously caused, finding hundreds of prisoners in abandonment, lack of punishment by the Law before that, usually reduces them as minimal consequence, since there are usually serious problems because of this area or, originated with arguments based on it.

Innovations that have brought improvements to the processes implemented, channeled and efficiently used energy and water, a recycling plant has been built the unit analyzed, however, remains isolated and perhaps inefficient efforts for the production required by the economic elements they contribute to state and national indicators.

With regard to the consumption of the mineral resource, there is an important research preamble, the calculation of so-called reserves, which would contribute entirely to the universal call to guarantee resources for the better living today and subsequent generations, could be affected by poor administrations, i.e. poorly performed calculations, poorly used farm designs, non-legalized extractions of small miners, loss of ore with value in earths formed or discarded as MEL by an evil or inefficient metallurgical process.

Based on these claims, the environmental impact on responsible production and consumption is contrasted based on the management and efficient use of natural resources, waste generation and sustainable practices, of which efforts are made, however, to national policies and priorities and the use of tools to monitor the effect of sustainable development, there are still numerous weaknesses, which promote complicated problems with NGOs and society at large.

As an indicator of responsible consumption, particular objectives remain to be met; the environmental impact to the landscape is perceived as aggressive and devastating, the way to restore it can slow down, but the impact leads to the same measurement and perception.

- *Sustainable Principle**: Life of Terrestrial Ecosystems***

The Sustainable *Living Principle of Terrestrial Ecosystems,* based on observations, is contrasting in its implementation, since the normative parameters selected for this study, are based on the official reports submitted to the authorities (EIM) and the effectiveness they have.

While, the parameters that EIM requires for environmental protection in this sense of ecosystems, they are described as very shallow, that is, they require declaring species in flora and fauna inhabitants of the areas to affect through an ordinary year, in order to protect species that migrate and/or flourish according to the spring-summer-autumn-winter seasons, and these studies become thorough, because they also require concrete actions for such protection, which is fulfilled, the effect is positive. However, the observation of the devastated landscape clouds this aspect and, while there is extraction of the ore, and in the places of prey, flora and fauna are absent.

The reality is that nature makes its way, on scheduled visits to the units, they were observed, in different locations: dam, mine and area of operation profit and refinery, such as areas or general areas, birds, rodents, animals own the area, artificial gardens and wild vegetation grow, in addition to the areas themselves restored and reforested, greenhouses in excellent condition; this leads to particular conclusions that the mining industry, if aggressive, but does not impede the life of ecosystems, if notorious for waste, but can also become investment and scientific research applied, versatile and kind to them. So on the one hand the reports seem to be very in efficient, in this sense, since with minimal efforts, ecosystems regenerate, their re-location, when required is manual, gives instant fruits, advantage that should be used to efficient processes and cooperate with responsible consumption and with care and above all minimization of waste.

A reference to the life of terrestrial ecosystems promotes the evaluation of the procedure for its preservation based on the indicators of the *Environmental Impact Manifest* (EIM) presented by mining projects to authorities (SEMARNAT), measuring the promotion of management practices to reduce degradation. While, on the one hand, it is described that the devastation by extraction and deposit of MEL's in dams,

severely harms the image and landscapes and, are these, considered serious environmental impacts, EIM does promote the protection of ecosystems, without considering that they are efficient, especially since it is noted that the agencies in charge do not formally apply the punishments imposed by the Law to those units that are not transparent in their daily environmental practices.

4. Final Conclusion

As a final conclusion, the efforts observed according to the environmental practices established in the unit analyzed in this research are described, to consider them in the strategic plans, as these present a significant gap in implementation.

It is based on what is described in the official reports (EIM), although this fact is considered a success in compliance with the regulations, however, in the field, the observations are more critical, the document points out actions or results that are not as effective when they are felt in reality; these differences are emphasized in large corporate-favored units, i.e. they capitalize on operating units, establish budget items, and their implementation in their productive areas, their facilities and infrastructure, equipment, processes, population support, is notorious and important sources of employment, not medium and small mining units. In the unit of ana precarious financial capacity is noted, its staff is inexperienced (there may be a direct relationship with the salary level), so their decisions are not effective and they are far from environmentally friendly, as they seek production goals first and foremost.

With regard to impacts or risks of environmental impact, important annotations, as part of the research, are listed as observations:

1. There are small, medium and large miners, that is, a subdivision is made to companies dedicated to mineral extraction (open pit mine and underground mine).
2. The country's mining law does not make a legislative difference to this subdivision.
3. As a social phenomenon, surrounding communities create dependence in all aspects: economic, educational, health, social.

RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE STUDIES

1. About the Sustainable Management Model

The product of this research, in its Sustainability-focused Management Model format, becomes a management strategy that can be used in the state's mining metal industry, and even the country. Its field validation opens up the possibility for metal mining units to measure the sustainable principles described and visualize areas of opportunity and environmental impact.

The metal mining industry in Mexico excels at its influence on economic indicators, so the importance of conducting studies that identify environmental impact risks and the correct alignment or not, with the sustainable principles suggested in the Agenda 2030. The improvements that, depending on this global alienation and above all theminimize of the risk of environmental impact, will help the stability that the sector provides to state and national economic indicators.

The Sustainable Management Model becomes a feasible proposal for Mexico's metal mining units, once through the research study carried out in a representative analysis unit of this sector, the implementation of this sector is promoted as a valid tool based on legislative parameters that recognize it as relevant and, original and important in giving timely follow-up to UN-suggested SDG´s to contribute to the environment and also to ensure mineral recourse to future generations without sacrificing those present.

Mexico's mining-metal sector influences the indicators of the mining-metallurgical industry and this in turn is within the 5 industrial sectors that formalize the country's economy. So the Sustainable Management Model becomes an instrument that allows companies important to the country to measure their real collaboration with the objective of the United Organizations, which are an effective co-act with the environment without punishing the country's economic indicators.

Implementing organizational culture, has become for Mexico, an imposed task of foreign tools and with foreign staff, also emphasizing the quality of the professionals and labor of the country for alternative positions and that are not of high organization, so that having a valid and reliable tool for strategic planning in the field of

Environmental Management , is to consider practicality in implementation, without fighting to establish a culture, since this Model is already part of Mexican culture, with international scope.

2. Recommendations for future studies – in field

1. Documenting best practices in the unit as a value-added collaboration, which in the first instance gives the opportunity to validate the Model and gives the possibility to standardize programs beyond just having the technical reports, such as the EIM.
2. It is recommended to open up the possibility of measuring more Legislative Parameters, due the 16 selected for this research study, are contained at EIM and fully validated in a single Sustainable Principle (Life of Terrestrial Ecosystems). In addition, more principles can be inserted and measured in the scheme and structure of the Sustainable Management Model.
3. The Model must be implemented through day-to-day activities. Measuring the awareness of four Sustainable Principles places the metal unit in promoter of global measurements under Mexican schemes, so that it does not alter the essence of everyday work.
4. It is recommended as a methodological utility, the implementation of the model in other units of the mining-metal sector of Mexico. The description of the results will provide sufficient information to feedback best practices so that effectiveness is not only perceived, but can be measured for the benefit of the mineral resource guarantees of current and future generations.
5. it is suggested to the metal unit analyzed, to quantitatively measure productivity indicators in the area of Environmental Management those results emanating from the implementation of the proposed Model.

3. Recommendations for future studies – in the Mining-metallurgical Sector

The Mining industry in Mexico shelters the metallic, non-metallic and metallurgy sector, the latest one is presented as Refineries. Extending the implementation of the Model to these sectors suggests other phases:

3.1 Metallic Sector:

a. Replicating the Sustainable Management Model, to take it to the entire state in mining-metal units, can be a first phase to document effectiveness and best practices; Also, make feedback and proposed improvements or area of opportunity to be more effective in seeking to meet the goals and objectives that sustainability suggests and thus ensure actions to mitigate environmental impacts.

b. Based on these results, the scope can be extended to a second phase, it can be implemented in other states of the Republic, which, because of their importance in the production of metals, are significant; basically the implementation of the Model follows the same methodology described in Chapter IV. Comparing results between states with equivalent economic indicators with respect to metal mining can show the trend or deviation from compliance with the 2030 Agenda.

3.2 Non-metallic sector:

a) Make a comparison with this sector, documenting in addition to the findings with reference to the alignment with the 2030 Agenda, the results of the correlation with an emphasis on the type of mines: open pits and underground mines, which have different environmental impacts by their nature. Perception studies can be options when it comes to open pit mining units, which would strengthen the sustainable principle of sustainable communities.

b) The Model is basically replicated with the same methodology, since the difference between mine types does not imply different regulations, so the implementation should be standardized. Although, the implementation in open pit mines could make new observations for changes in this regulation, since by nature, the damage to the environment is greater and noticeable.

3.3. Metallurgy (Refineries):

The reality of refineries in Mexico with reference to the regulations protected by the Mining Law, is basically new, the age of these, dates back more than 100 years, and the law that protects the environment was born in the country in the 80's, so the

history of pollution and devastation by this part of the mining sector, is an environmental, economic, political and social problem.

a) Within the metallurgical sector the Sustainable Management Model, due to its flexibility can focus more on the Parameters of Law, which must be stricter, measurable, so numerical information can even be developed and therefore quantitative studies.

b) It is recommended to use the same methodology for the implementation of the Sustainable Management Model.

4. Scope and limitations compared to expected results

The research recognized that the environment is a priority objective in the metal mining industry. It is important that the Sustainable Management Model be implemented to consolidate the intention to measure the Sustainable Principles that will also allow us to measure alignment with the 2030 Agenda; in addition, the country's regulations are met.

In this sense, the contribution that this study makes is to establish an auxiliary tool for the strategy of aligning business management needs with the urgent implementation of the Environmental Agenda. This provides an effective scope when trying to implement in the metal mining sector of the state of San Luis Potosí and in the phases of this recommendation, the following sectors: non-metallic and metallurgy in the rest of the country.

This research fulfilled its purpose and identified areas of opportunity in the implementation, monitoring and evaluation of the environment. Implementing the Model in an underground metal ore mine, it allowed to observe that the information obtained provides data necessary to know the reality within environmental strategies. It is for this reason that it is possible to think of future research studies based on the perception outside the unit.

5. Some aspects that were not covered in the study

It is important to note that while the scope of the Sustainable Management Model can increase its effectiveness in practice, the benefits obtained can be channeled and

extended favorably to the entire mining-metallic sector and even the non-metallic and metallurgical sector. Gaining benefits from environmental activities will depend on the management of each mining unit and its own strategies. Other units will also depend on the decisions of their corporate; however, the biggest problem will be that the really regulation changes for the good of the environment, since the Model when implemented in the section measuring legislative parameters is met, but requires that it apply for each type of operational unit, referring to the type of mine (underground or open pit) and refineries.

In Mexico, during the global crisis caused by the COVID19 health pandemic, all economic sectors were affected by 2020 and the path set out in 2021. Foreign investment as a miner in addition to the public policies of the current government has denigrated the sector and sided with giant corporates, leaving the country and postponing and even suspending mining exploration and operation projects. Abandonment of affected units can be a major trigger for environmental impacts; the Model would have to be adapted in the legislative part (once again), to encompass the reality of the devastation caused after the closure of operability.

FINAL REFLECTION

The negative effects of mining-metallic industrial development are seen in ecology and in the societies it affects (Martínez and Bednarek, 2018). Environmental problems, due to poor practices within the mining sector, are the result of the absence or lack of application of regulatory guidelines and legislation over time, as sites contaminated with organic and inorganic compounds derived from the processes of exploitation, extraction and the benefit of minerals have been identified. (Volke and Velasco, 2002).

Efforts in this regard have not been expected, tasks, methods, techniques, strategies, environmental care plans have been implemented within the mining industry, however, as it is an aggressive sector by nature, its commitment grows and should become more effective, but above all it must observe practices and requirements at the universal level, not only contemplate the superficial compliance of what the Law imposes.

This research proposes an alternative that manages this linkage, through the presentation of a Sustainable Model that is measured by well-known schemes, forced by the authorities, but with a forward-looking vision set out on a platform exercised by universal principles.

Viota (2017), states that the environmental dimension must be implemented with thought of conservation and real protection of natural resources, by then work on the functioning of Sustainable Development and that future generations are not compromised. This relationship is resumed in the construction of the proposed Sustainable Management Model; through elements, the platform offered by Environmental Management is sized with pillars strengthened with Universal Sustainability Principles and measured with Legislative Parameters that land the environmental practices of the country's mining units.

This Sustainable Management Model can be a solid response to address some of the challenges of sustainable development expressed by the 2030 Agenda, in search of the joint well-being of man in nature (Viota, 2017). As integrated solutions are required through new approaches that simultaneously cover all the SDGs, this Model presents a practical, flexible and functional option for the Mining-Metal Industry of Mexico, as it allows official compliance, considering the universal requirements.

The conservation of a safe, clean, healthy and sustainable environment is vital for the well-being of human beings and the guarantees offered by the right to enjoy them. The global situation of the environment, far from being ideal today, events such as climate change, deforestation, biodiversity loss, excess pollution, become threats. Current environmental policy must continue its work and make deeper efforts to further generate real benefits, as there are improvements in quality of life and the environment, innovation and job creations (Viota, 2017), but there are still growing environmental challenges, which to address them, fundamental changes need to be made in production and consumption systems mainly, in addition to every organization, community, society and individual.

The flexibility of the Model allows the inclusion of various legislative parameters, including quantitative measurements, for example environmentally focused productivity indicators and, at the global or international level, allows the inclusion of trends such as the circular economy.

Traditional development models emphasize the economic and social dimension of development without regard to environmental impacts; because of this, the presenting of a Sustainable Management Model, with a base structure in environmental policies supported by a formal management, promotes this research as original, relevant, current and important, also complying, with a format of a scientific study that is presented as a practical response, relevant and adjusted to the current needs of the Mexican Mining-Metallic Industry.

ANNEXES

Anexo 1. Texto contemplado para la *solicitud de oportunidad* de realizar el estudio en las unidades de análisis seleccionadas.

San Luis Potosí, S.L.P., a (Fecha)

NOMBRE DEL CONTACTO
PUESTO
EMPRESA

Por este conducto, me presento ante usted, como Doctorante en el área de Gestión de la Facultad de Ciencias Sociales de la Universidad de Lodz en Polonia, y como tal desarrollo un tema de tesis centrado en una línea de investigación Ambiental. Mi interés particular, es poder contribuir desde el área del conocimiento a un estudio de relación de principios internacionales de sustentabilidad e parámetros nacionales avalados por la Ley Minera del país, a través de la Secretaría de Medio Ambiente y Recursos Naturales, por el tema ambiental.

El Estudio analiza las prácticas de Gestión Ambiental que ocho unidades minero-metalúrgicas realizan y se miden en riesgos de impacto e impactos ambientales que se presentan, a partir de la identificación de características de las etapas de la industria minera y en relación con lo identificado previamente en la literatura, en cuanto a la relación de *principios sustentables-parámetros nacionales*.

La estrategia a seguir, es que una servidora en un rol de investigadora, en algunas visitas programadas, obtenga según instrumentos construidos ex profeso para este estudio, información que permitirá hacer algunas observaciones, que expresen de forma científica cómo el sector minero-metalúrgico en México, colabora o no, con las observaciones de Ley e Internacionales, y cómo pudieran integrar temas o prácticas en su Gestión Ambiental. Todo ello sin comunicar datos individuales.

Su apoyo para ser parte de la muestra de este estudio, es indispensable para la correcta puesta en marcha de la estrategia metodológica establecida. Personalmente, si aceptan mi solicitud, realizaré las observaciones y anotaciones pertinentes, siguiendo las guías antes mencionadas, en compañía de algún representante ambiental o miembro de su organización.

Estoy consciente de la importancia de la confidencialidad requerida por las unidades a estudiar, por lo que además de presentarme como persona que promueve el desarrollo de proyectos mineros como prioridades económicas para el crecimiento del país, estoy dispuesta como estudiante íntegra, a firmar algún documento que requieran para este fin, de ser política de la empresa.

Agradezco de antemano la atención a esta solicitud, quedo en espera de su respuesta, deseando poder colaborar con conocimiento formal a la educación y al sector Minero Metalúrgico de México.

M.C. Rosa Elia Martínez Torres,
Doctorante Universidad de Lodz, Polonia,
Docente Instituto Tecnológico de San Luis Potosí,
Colaboradora Minera Tierra Adentro, S.A. de C.V.

Anexo 2. Carta de presentación de la investigadora.

Lodz, Polonia., a (Fecha)

NOMBRE DEL CONTACTO
PUESTO
EMPRESA

Presento a Usted, a la **M.C. ROSA ELIA MARTÍNEZ TORRES**, como alumna del programa de Doctorado en Gestión, de la Facultad de Ciencias Sociales de la Universidad de Lodz en Polonia, quien ha recurrido a la empresa que dignamente representa, solicitando la oportunidad para implantar una estrategia de investigación acerca de las prácticas ambientales que realizan al interior y exterior de la organización.

El Estudio consta de una serie de visitas programadas, para obtener información mediante la aplicación de instrumentos construidos ex profeso que permitirán hacer algunas observaciones, que expresen de forma científica, cómo el sector minero-metalúrgico en México, colabora o no, con las observaciones de Ley e Internacionales y, cómo pudieran integrar temas o prácticas en su Gestión Ambiental. Todo ello sin comunicar datos individuales.

La tesis doctoral que surja a partir de este estudio, analiza las prácticas de Gestión Ambiental de ocho unidades minero-metalúrgicas, lo que permitirá generalizar los hallazgos individuales, hacia el sector, a favor del medio ambiente.

Agradecemos su interés por participar promoviendo la cultura de la gestión del conocimiento, mediante la oportunidad brindada a nuestra doctorante.

Prof. Dr. Hab. Ursula Zulawska
Universidad de Lodz, Polonia,

Anexo 3. Guía de Observación

NATURALEZA DEL PROYECTO				RIESGOS DE IMPACTO E IMPACTOS AMBIENTALES OBSERVADOS	HORIZONTE			REVERSIBILIDAD			PERSISTENCIA		EXTENSIÓN			MEDIDA CORRECTIVA					INTENSIDAD		
EXPLORACIÓN	EXPLOTACIÓN	BENEFICIO	REMEDIACIÓN		C	M	L	C	M	L	T	P	P	P	T	d.P	d.E	d.D	d.A	S/P	B	D	N
Ubicación del yacimiento respecto de la población																							
Tipo de metales																							
	Diseño de la mina																						
	Sistema de explotación																						
		Elección de sistema de beneficio de flotación, cianuración, concentración por gravedad...																					
			Jales y contaminantes																				
			Programas de cierre																				

Industria, Innovación e infraestructura			
	Declaraciones Unidad de análisis	Evidencia mostrada	Observaciones de apoyo
¿De qué dimensiones requieren una plaza para barrenar a diamante en exploración y, qué protocolos siguen para el manejo de las plantas a desalojar igual para el trazo de caminos temporales para acceso a las plazas?			
¿Cómo controlan el material de aceites en posibles fugas de equipo, cambios de aceite programado y derrames de depósitos en sus talleres y plazas de exploración?			
¿Qué normas aplican para controlar el combustible por posible falla en el contenedor general (talleres-operación)?			
¿Cómo designa las áreas para realizar depósitos de material (terreros-tepetateras) en relación al medio ambiente?			
¿Cuentan con sistema de recolección de material catalogado como residuo peligroso; se aplica un control del mismo sistema para residuo peligroso?			
¿Cuentan con equipo de emergencia y/o realizan paros en caso de fugas de jales en su bombeo y/o traslado del mismo a sus presas o jaleros?			

Anexo 4. Lista de Verificación

TIEMPO/DEMIDA/ÚTIL					NOTAS	HORIZONTE			REVERSIBILIDAD			PERSISTENCIA		EXTENSIÓN			MEDIDA/CORRECTIVA					INTENSIDAD		
EXPLORACIÓN	EXPLOTACIÓN	BENEFICIO	REMEDIACIÓN			C	M	L	C	M	L	T	P	P	P	T	d.P	d.C	d.D	d.R	S/P	B	D	N
No declararse correctamente. El proyecto no termina al justificar una operación, sino hasta que el recurso seAgota.																								
Verificación de proyecciones laterales y profundidad.																								
Verificación correcta de costeabilidad.																								
	Determinado por la exploración y costo-beneficio.																							
	Producción de material de obra al prolongar la vida.																							
	Cambios de equipo de todoElpo.																							
		VolumenExplotado.																						
		Desgaste y mantenimiento del equipo.																						
		Uso de suministro en mina:Agua,Bactivos																						
			ConstrucciónDelPresaEllales.																					
			Aumento en la capacidad delaPresaDelpos.																					

REFERENCES

1. AECID, (2017). Estudio sobre la contribución de la empresa a la Agenda de los ODS. España: Cooperación española.
2. AIME, (2000). Mining Engineering Handbook. SME.
3. ANM, (2000). Etapa de Exploración. Colombia: Agencia Nacional Minera.
4. André, P., y Delisle, C., (2004). Environmental Assessment for Sustainable Development. Canada: Presses Internationales Polytechnique.
5. Aguilera, R., y Santana, C., (2017). Fundamentos de la Gestión Ambiental. Samborondón-Ecuador: Universidad ECOTEC.
6. Arellano, D., (1998). Case Studies Methodology in Social Sciences. Elemental bases. México: Centro de Investigación y Docencia Económicas.
7. Arranz, J., Alberruche, E., (2008). Minería, medio ambiente y gestión del territorio. España: Gráficas Monterreina.
8. Arranz, J., (2015). *Rehabilitación o remediación de espacios degradados por minería a cielo abierto.* Investigación, Desarrollo e Innovación en España. España: Instituto Geológico y Minero de España.
9. Arvadinitis, N., (2014). Minerals in your life. España: EuroGeoSurveys.
10. Arzaluz, S., (2005). *La utilización del estudio de caso en el análisis local*. Región y Sociedad, Vol XVII, No 32. México.
11. Badilla, L., (2006). Fundamentos del paradigma cualitativo en la investigación educativa. Revista de Ciencias del Ejercicio y la Salud, Vol. 4, No. 1 pp. 42-51.
12. Balkau, F., (1999). *Abandoned mine sites. Problems, issues and options.* Protection of the environment and natural resources.
13. Ballina, F., (2000). Paradigmas y perspectivas terórico-metodológicas en el estudio de la Administración. IIESCA.
14. Banco de España, (2017). Situación y Perspectivas de la Economía Mundial al comienzo de 2017. Artículos Analíticos. Banco de España. Recuperado el 10 de enero de 2018 de: https://www.bde.es/f/webbde/SES/Secciones/Publicaciones/InformesBoletinesRevistas/ArticulosAnaliticos/2017/T1/fich/beaa1701-art8.pdf
15. Barettino, D., Arranz J., Martinez, B., (1998). Ordenación Minero-ambiental de los recursos en el sector de la piedra natural. España.
16. Bascones, M., Gallego, E., (1993). Ordenación del territorio y actividades extractivas. Problemática geoambiental y desarrollo. V reunión nacional de geologia ambiental y ordenación del territorio. Pp 35-52.
17. Bebbington (2009).
18. Bedeian, A., (1983). Organizations: theory and analysis. USA: The Dryden press
19. Benítez, C., (2019). El desarrollo sostenible como solución de la tensión socio-ambiental. Caso de estudio. México: UNAM.
20. Berger, P., Luckman, T., (2003). La construcción social de la realidad. Argentina: Amorrortu.
21. Bermúdez, H., (2011). La inducción general de la empresa, Entre um processo administrativo y um fenómeno sociológico. *Universidad & empresa, vol.13, num 21*. Colombia.

22. Bernal, C., (2000). Metodología de la investigación para administración y economia. Colombia.
23. Bitel, L., y Niewstrom, J., (1992). Lo que todo supervisor debe saber. Sexta edición. México: McGrawHill.
24. Boiral, O., (2005). *Desarrollo Sostenible y gestión medio ambiental.* Nuevo pensamiento administrativo. Colombia: Ed. Universidad del Valle.
25. Bonnicksen, T., Lee, R., (1982). *Biosocial Systems Analysis: an approach for assessing the consequences of resources policies.* Journal of environmental management, no 15, pp 47-61.
26. Bozinovic F., Donoso, E., Novoa, F., Simonetti, J., (2013). Innovación en la gestión ambiental: el caso de insumos biotecnológicos creados sobre la base de microorganismos nativos. Innovación basada en conocimiento científico. Chile: Academia Chilena de Ciencias.
27. Bref., (2006). Reference document of best available techniques of the management of tailings and waste rock mining activities. European Union.
28. Cabrero, E., (1996). Los dilemas de la modernización municipal. Estudios sobre gestión hacendaria en municipios urbanos de México. México: Porrúa.
29. Call, R., Savelly, J., (1990). *Open pit rock mechanics.* Surface Mining. USA: Littleton.
30. CAMIMEX, (2017). INFORME ANUAL 2017. Situación de la minería en México. CÁMARA MINERA DE MÉXICO A.C. recuperado el 12 de enero de 2018 de: https://www.camimex.org.mx/files/9515/0058/4028/02-Info17.pdf
31. CAMIMEX, (2018). Situación de la Minería en México. Informe anual.
32. Campoy, T. y Gomes, E. (2009). Técnicas e instrumentos cualitativos de recogida de datos. En Pantoja, A. (Coord.). Manual básico para la realización de tesinas, tesis y trabajos de investigación (pp.275-302). Madrid: EOS Universitaria.
33. Cerda, H., (1991). Medios, Instrumentos, técnicas y métodos en la recolección de datos e información. Los elementos de la Investigación. Venezuela: UNA.
34. Cárdenas, M., (2009). Construcción y validación de instrumentos de medida para la recolección de datos. Métodos de Investigación social. Ecuador: Ed. CIESPAL.
35. Carrillo, G., (2014). Seguimiento y Recomendación: CCNDS/II/13/05 Minería y Medio Ambiente. México: SEMARNAT.
36. CFI-GBM, (2007). Environmental, health and safety guidelines for mining. Recuperado el 10 de agosto de 2020 de: http://www.ifc.org/ifcext/sustainability.nsf/attachmentsbytitle/gui_EHS-Guidelines2007_Mining/$FILE/Final+-+Mining.pdf
37. Clausell, M., (2010). Historia de la Plata Mexicana. México: AAPAUNAM Academia, Ciencia y Cultura.
38. Colby, M., (1991). *Environmental Management in devolpment: the evolution of paradigms.* Ecological Economics, vol 3, pp 193-213.
39. Coneza, V., (1993). Guía metodológica para la evaluación del Impacto Ambiental. España: Mundi-Prensa.
40. Constitución Política de los Estados Unidos Mexicanos, (2019). DOF 09-08-2019, recuperado de https://mexico.justia.com/federales/constitucion-politica-de-los-estados-unidos-mexicanos/
41. Coordinación General de Minería (2014). Guía para conocer las etapas del proceso productivo para la pequeña Minería. México: Secretaría de Economía.

42. Coordinación General de Minería (2015). Guía de procedimientos mineros. Secretaría de Economía. México. Recuperado el 25 de enero de 2018 de: https://www.gob.mx/cms/uploads/attachment/file/112613/guia_de_procedimientos_mineros_0414.pdf
43. Corbetta, P., (2003). Metodología y técnicas de investigación social. España: McGrwHill.
44. Correa, A., (2000). *Situación actual de la explotación de canteras en el Distrito Capital*. Revista de ingeniería e investigación 45. Colombia.
45. Crespo, R., (2000). *The Epistemological Status of Managerial Knowledge and the Case Method*. Proceedings Latin America, pp 210-218
46. Creswell, J., (2013). Qualitative inquiry and research design. 3rd edition. USA: SAGE.
47. Crispín, A., Sánchez, M., (1992). *La pequeña y mediana minerías en México*. Latin American Studies, 12, pp 55-76.
48. Chávez, M., (2015). Los pasivos ambientales mineros: diagnóstico y propuestas. Perú: Red Muqui.
49. De la Maza, C., (2001). *NEPA´s influences in developing countries: the chilean case.* Environmental impact assessment, Vol 21, pp 169-179.
50. De la Maza, C., (2007). *Evaluación de Impactos Ambientales.* Manejo y Conservación de recursos forestales. Chile: Editorial Universitaria.
51. Denzin, N., & Lincoln, Y., (Eds.) (2000). Handbook of Qualitative Research. London: Sage Publication Inc.
52. Denzin N. and Lincoln Y. (2012). El campo de la investigación cualitativa: Manual de investigación cualitativa, vol. 1. España: Gedisa.
53. Diario Oficial de la Federación, (2018).
54. Díaz, M., (2015). Implementación de un sistema de gestión ambiental para la empresa Dizamar. Colombia: Corporación Universitaria Lasallista.
55. DOF, (2018). Ley Orgánica de la Administración Pública. Diario oficial de la Federación. Recuperado el 7 de noviembre de 2019 de: http://www.diputados.gob.mx/LeyesBiblio/ref/loapf
56. Downey, L., Bonds, E., & Clark, K., (2010). *Natural Resource Extraction, armed violence and environmental degradation.* Organ Environ. Vol 23, pp 417-445.
57. Dulzaides, M., Molina, A., (2004). *Análisis documental y de información: dos componentes de un mismo proceso.* ACIMED, vol 12, num 2. Cuba.
58. Duque, (2017).
59. EMDELP SAC, (2016). Manual de Minería. Perú.
60. ELAW, (2010). Guía para evaluar EIAs de proyectos mineros. USA: Alianza mundial del derecho ambiental (ELAW).
61. El Serafi, S., (1994). *Sostenibilidad, medida de ingreso y crecimiento.* Desarrollo Económico Sostenible. Avances sobre el Informe Brundtland. Colombia: Uniandes.
62. Escudey, M., Martinez, E., (1998). Evaluación y Decisión multicriterio: reflexiones y experiencias. Chile: Universidad de Santiago.
63. Espinoza, K., Hernández, A., Mantilla, E., (2016). *La participación de la minería sus beneficios económicos en Colombia y Perú*. In Vestigium Ire. Vol. 10, pp 208-228.
64. Estevan, M., (1984). Evaluación del Impacto Ambiental ITSEMAP. España: ITSEMAP.

65. Estudios Mineros S.A.C (s.f.). Manual de Minería. Perú: Estudios Mineros S.A.C., recuperado el 18 de octubre de2017 de http://www.estudiosmineros.com/ManualMineria/Manual_Mineria.pdf
66. Exposición temporal Museística, (1989). El arte de la platería mexicana, 500 años. México: Centro cultural Arte contemporáneo.
67. Falé, P., Henriques, P., Midoes, C., Carvalho, E., (2006). *Reordenamiento de actividades extractivas como instrumento de planeamiento regional.* Boletín geológico y minero, vol 117, pp 277-288.
68. Farfán, M., (2010). Análisis de la vigencia del paradigma de utilidad en la contabilidad moderna. Lúmina 11, pp 260.
69. Feagin, J., Orum, A., Sjoberg, G., (1991). A case for case study. USA: University of North Carolina Press.
70. Fierro, J., (2012). Algunos aspectos importantes de la Minería en Colombia. II Jornada Nacional de Encuentros en Defensa de la vida.
71. Flores., B., (2019). Minería metálica. México: UNAM
72. Fowler, B., Goering, P., (1991). Metals and their compounds in the environmental. USA: VCH Weinhem.
73. Franklin, J., Maurice, B., (1991). Rock engineering applications. Singapure: McGrawHill.
74. FUNDAR, (2002). Minería, comunidades y medio ambiente. México: Centro de Análisis e Investigación.
75. Garay, L., (2013). Fundamentos para superar el modelo extractivista. Colombia: Contraloria General de la República.
76. García, A., (2002). Tratamiento y análisis de la documentación. Cuba: Universidad de la Habana.
77. García, C., Portales, L., Camacho, G., Arandia O., (2010). Instrumento de evaluación de Sustentabilidad y Responsabilidad Social en Pymes. Revista de Administración y Organizaciones. UAM: México.
78. García, D., (2019). Principales ventajas y desventajas del outsourcing. Memorias de Congreso Virtual Internacional en Iberoamérica, recuperado en mayo 2021 de https://www.eumed.net/actas/19/desarrollo-empresarial/13-principales-ventajas-y-desventajas-del-outsourcing.pdf
79. García, J., (1992). Evaluación de programas de planificación familiar. Guía detallada para administradores y evaluadores. Colombia: Ed. Pathfinder Internacional-Profamilia.
80. García, R., (1992). Evaluación Geoestadística del proyecto Minero Cerro de San Pedro, S.L.P. México: UNAM.
81. Garza, R., González, L., (1997). *Ciencia y Desarrollo Sostenible.* Ecosistemas y poblaciones, ciencia y desarrollo sostenible. México: Thompson Editores.
82. Giarracca, N., Teural, M., (2010). Disputas por los territorios y por los recursos naturales: el modelo extractivo. Revista ALASRU, (5), pp. 113-133.
83. Gilliland, M., Risser, P., (1977). *The use of system diagrams for environmental assessment.* Ecological Modelling, Vol 3, pp 188-209.
84. Gómez, T. (2012). RSE y desarrollo sustentable. En: Raufflet, E., Lozano, J., Barrera, E. y García, C. eds., *Responsabilidad social empresarial*, 1st ed. Naucalpan de Juárez, México: Pearson.

85. Góngora, J. (2013). Evolución reciente de la minería en México. Comercio Exterior. México. Recuperado el 20 de enero de 2018 de: http://revistas.bancomext.gob.mx/rce/magazines/157/1/evolucion.pdf
86. González, B., (2019). La pequeña y mediana minería metálica en el contexto de la munidalización capitalista. El caso del distrito minero de Zimapán, Hidalgo y sus implicaiciones territoriales. México: UNAM.
87. González, D., (2006). Riesgo ecológico en la zona minera de Villa de la Paz, San Luis Potosí. México: UASLP.
88. González, F., y Camprubí, A., (2010). *La pequeña minería en México*. Boletín de la Sociedad Mexicana. México: UNAM.
89. Goode, W., Hatt, P., (1976). Métodos de investigación social. México: Trillas.
90. Gudynas, E., (2002). Una mirada histórica al desarrollo sustentable. Ecología, economía y ética del Desarrollo Sostenible. 2da Ed. Argentina: Universidad Nacional del Comahue.
91. Guia_ODS_ PM_20170215 (2017). Foro político de alto nivel naciones Unidas: http://www.pactomundial.org/wp.content/uploads/2017/02/Guia_ODS_PM_2017 0215_web.pdf.
92. Gutiérrez, R., (2014). Introducción al estudio del Derecho Ambiental. 8va ed, México: Porrúa.
93. Guzmán, A., (2017). Gestión empresarial e innovación desde la Educación Especial. Revista UCA Profesional Vol.1, Núm.1, pág. 22. Costa Rica: Universidad Florencio del Castillo.
94. Hernández, M., (2019). Análisis jurídico de la Gestión Ambiental en México. México: UNAM.
95. Hernández, R., (2014). Metodología de la Investigación, 6ta edición. México: McGrawHill.
96. Hernández, R., (2018). Metodología de la Investigación, 7ma edición. México: McGrawHill.
97. Hernández, R., Mendoza, C., (2018). Metodología de la Investigación: Las rutas cualitativa, cuantitativa y mixta. 2da edición. México: McGrawHill.
98. Herrera, (2018).
99. Herrera, J., (2006). Introducción a los fundamentos de tecnología minera. España: Universidad Politecnica de Madrid.
100. Herriott, R., Firestone, W., (1983). Multisite Qualitative policy research in education. A study of federal experience. USA: National Inst. of Education ED.
101. Hustrulid, (1982). Mining operations & studies. European Union.
102. Hyman (1968). El modelo del experimento y el control de las variables. USA: The Free Press.
103. IIED/WBCSD, (2002). Informe final del proyecto del Proyecto de Minería, Minerales y Desarrollo Sostenible. IIED.
104. IMSS (2017). Informe de labores y programa de actividades 2016-2017. México: Secretaría de Salud
105. INACAP, (2001). Características de la industria extractiva minera. Chile: INACAP.
106. INAFED (2010). Enciclopedia de los Municipios y Delegaciones de México. Instituto para el Federalismo y el Desarrollo Municipal. Secretaría de Gobernación. México.

107. INEGI (2011). La industria minera ampliada. Censos económicos 2005 y 2009. México: INEGI.
108. INEGI, (2017). Producto interno bruto de México durante el cuarto trimestre de 2016. BOLETÍN DE PRENSA NÚM. 103/17. Instituto Nacional de Estadística y Geografía. Secretaría de Economía. Recuperado el 10 de enero de 2018 de: http://www.inegi.org.mx/saladeprensa/boletines/2017/pib_pconst/pib_pconst2017_02.pdf
109. Isla, P., (2002*). Breve análisis de la Legislación Minera*. Revista Jurídica virtual del Instituto de Investigaciones Jurídicas. UNAM: México https://revistas-colaboracion.juridicas.unam.mx/index.php/arsiuris/article/viewFile/2443/2297
110. Jaeger, J., (1969). Fundamental of Rock mechanics. England: Methuen and Co. Ltd.
111. Jiménez, I., Molina. J., (2006). *Propuesta de medición de la productividad en minería de oro vetiforme y reconocimiento de estándares productivos sostenibles*. Boletín de Ciencias de la Tierra. Colombia: UNC.
112. Kuhn, T., (1982). La estructura de las revoluciones científicas. México: Fondo de Cultura Económica.
113. Labra, O., (2013). *Positivismo y Constructivismo: un análisis para la investigación social.* Rumbo TS, Núm. 7. Chile: UCCH.
114. Lafuente, C., Marín, A., (2008). *Metodologías de la Investigación en las ciencias sociales: fases, fuentes y selección de técnicas*. Revista Escuela de Administración de Negocios, Colombia, pp 5-18.
115. Lang, M., (1999). *Azogueria y amalgamación. Una apreciación de sus esencias quimico-metalúrgicas*. LLULL, vol. 22, pp 655-673
116. Latouche, S., (2007). Sobrevivir al desarrollo. España: Icaria Editorial.
117. Leal, J., (1997). Guías para la Evaluación del Impacto Ambiental de proyectos de Desarrollo Local. Chile: ILPES.
118. Left, E., (2000). Globalización, ambiente y sustentabilidad del desarrollo. México: Siglo XXI.
119. Left, E., (2004). Racionalidad ambiental. La reapropiación social de la naturaleza. 1ra ed. México: Siglo XXI.
120. Left, E., (2007). Saber ambiental: Sustentabilidad, Racionalidad, Complejidad, Poder. México: Siglo XXI.
121. Ley Minera, (2014).
122. Ley Orgánica de la Admnistración Pública, (2018).
123. LOM, (2015). Guía sobre control geotécnico en minería subterránea. España: Universidad Politénica de Madrid.
124. López, M., Pérez, A., (2018). Pruebas de lixiviación como evaluación ambiental de materiales. México: SCT.
125. López, L., Valverde, C., y Figueroa M., (2018). Pueblos Mágicos, una visión interdisciplinaria. México: UNAM, UAM.
126. Lowrie, R., (1997). *Of U.S. Minerals and morals.* Engineering & Mining Journal, oct, 1997.
127. Macbride, W., Bei, W., (2001). *Mining law and "enviromining" law section current mining law from around the world series*. Mineral Resources Engineering. Imperial College Press.

128. Martínez, M., (2004). Ciencia y Arte en la Metodología Cuantitativa. México: Editorial Trillas.
129. Martínez, P., (2006). El método del estudio de caso: estrategia metodológica de la investigación científica. Pensamiento y Gestión núm. 20. Colombia: Universidad del Norte.
130. Martínez, R. (1998). La verdadera energía de las empresas. Revista GEOMIMET. México: AIMMGMAC.
131. Martínez, R., (2018). Informe técnico 2018. ASI.
132. Martínez, R., (2000). Informe Técnico La Perreña. Edición interna Peñoles.
133. Martínez, R.E., y Bednarek. M., (2018). *Fundamentos para construcción de Instrumento Ambiental para la Industria Minero-metalúrgica*. Revista de Arquitectura y Diseño. España: ECORFAN.
134. Martínez, R.E., Bednarek, M., Rivera, P., Ojeda, M., (2019). *Principios Sustentables y Parámetros Legislativos en una mina subterránea en México. Caso de Estudio*. Revista de Desarrollo urbano y Sostenible. Bolivia: ECORFAN.
135. Martínez, R., y Martínez, R.E., (2019). *Innovación técnica en Minería*. Revista GEOMIMET. México: AIMMGM.
136. Martínez, R.E., y Martínez R., (2015), Glosario de términos Minero. Lenguaje coloquial con enfoque industrial, INDAUTOR: 03-2015-121409583500-0: México.
137. Martínez, R.E., y Rivera, P., (2018). *Articulación de los Objetivos de Desarrollo Sostenible y la Legislación Ambiental en la Industria Minera*. México: REMINEO.
138. Martínez, R.E., y Rivera, P., (2018). *Prácticas de Gestión Ambiental en industria minera. Caso de estudio*. Firmy rodzinne-zarzadzanie, rozwój, przedsiebiorczosc. Polonia: SAN.
139. Massolo, L., (2015). Introducción a las herramientas de gestión ambiental. Facultad de ciencias exactas., Universidad Nacional de la Plata.
140. Mauthner, N., Parry, O., y Backett, K., (1998). The data are out there, or are they? Implications for archiving and revisiting qualitative data. Sociology, 32 (4), pp. 46-68.
141. Mayntz, R., Holm, K., Hübner., (1993). Introducción a los métodos de sociología empírica. España: Alianza Editorial S.A.
142. Melo, R., (2011). Evaluación de un pasivo ambiental metalúrgico. México: UASLP.
143. Mendieta, G., (2015). Informantes y muestreo en investigación cualitativa. Investigaciones Andina, vol 17, núm 30, pp 1148-1150.
144. Mendizabal, R., (1996). Métodos y Técnicas. This file was converted with TextToHTML - (c) 1995 Logic n.v. - Kris Coppieters
145. Milena., A., (2013). Lineamientos para la planificación del sistema de gestión ambiental bajo la norma ISO 14000 en la fuerza naval del Caribe. Bolivia: Universidad Pontificia Bolivariana.
146. Ministerio de ambiente y medio rural y marino, (2011). Guía de Buenas Prácticas Ambientales. España: UGT.
147. Molinari, G., y Scaramellini, N., (2018). Las áreas funcionales en las organizaciones. Argentina: EDULP.
148. Monreal, R., y Hernández, P., (2014). Mi México es minero. Edición especial, Revista GEOMIMET. México: AIMMGMAC
149. Morales, E., Estrada, R., (2006). Iniciativas voluntarias para la responsabilidad Ambiental Corporativa en la Industria química. Administración y Organizaciones.

Recuperado el 15 de septiembre de 2017 de http://web.a.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=5&sid=ea572cbd-c648-4086-8e26-7d0d996f6c36%40sessionmgr4009

150. Morán, S., (2012). *Metodología e investigación científica en las ciencias sociales. Especial referencia a la disciplina de relaciones internacionales*. Metodología para Investigaciones de alto impacto. México: DYKINSON S.L.
151. Morán, R., (2013). Preguntas y respuestas sobre minería. Argentina: Greenpeace.
152. Moreno, C., y Chaparro, E., (2008). Conceptos básicos para entender la legislación ambiental aplicable a la industria minera en los países andinos. CEPAL, ONU: Chile.
153. Muradian & Alier (2002).
154. Nachmias, C. y Nachmias D., (1992). Research methods in the social Sciences. USA: St. Martin´s Press.
155. Naredo, J., (1996). Sobre el origen, el uso y el contenido del término sostenible. En la construcción de la ciudad sostenible. España: Ed. Ministerio de Obres Públicas, Transportes y Medio Ambiente.
156. Naredo, J., (1999). Sobre la sostenibilidad de los sistemas. Desarrollo económico y deterioro ecológico. España: Fundación Argentaria.
157. Naredo, J., (2006). Raíces económicas del deterioro ecológico y social. Más allá de dogmas. España: Siglo XXI de España.
158. Nero, G., (2005). *La problemática de recuperación ambiental de áreas mineras degradadas a nivel nacional.* Encuentro de comunidades mineras. CM Aljustrel.
159. Neuman (1994). Social Research Methods. Qualitative and quantitative approaches. USA: Allyn and Bacon.
160. NOM-001-SEMARNAT-1996
161. NOM-133-SEMARNAT-2000 (especificaciones de manejo para protección ambiental-bifenilos policlorados
162. NOM-138-SEMARNAT/SSA1-2012
163. NOM-147-SEMARNAT/SSA1-2004
164. NOM-155-SEMARNAT-2007 (requisitos de protección ambiental para sistemas de lixiviación de Oro y Plata),
165. NOM-159-SEMARNAT-2011 (requisitos de protección ambiental para sistemas de lixiviación de Cobre) y,
166. NOM-141-SEMARNAT-2003 (procedimiento para caracterizar jales, preparación del sitio, operación y post-operación de presas de jales).
167. Nordberg, G., (1998). Metales: propiedades químicas y toxicidad. Enciclopedia de la salud y seguridad en el trabajo. España: Ministerio de trabajo y asuntos sociales.
168. Nuñez, A., (2005). Sistema de Indicadores mineros para la explotción sostenible de los recursos minerales. Revista Minería y Geología. Instituto Superior Minero Metalúrgico: Cuba. Repositorio: Redalyc. Recuperado el 6 de febrero de 2017 de https://www.redalyc.org/pdf/2235/223516049004.pdf
169. Oblaser, Chaparro, (2008).
170. ODG, (2002).
171. Orellana, D., Sánchez, M., (2006). *Técnicas de recolección de datos en entornos virtuales más usadas en la investigación cualitativa.* Revista de investigación Educativa, vol 24, núm 1. Pp 205-222.

172. Organización de las Naciones Unidas, (1984). Naciones Unidas y el desarrollo. Recuperado de http://www.cinu.org.mx/temas/desarrollo/desarrollo.htm.
173. Organización de las Naciones Unidas, (1990). Impacto ambiental de la contaminación hídrica producida por la refinería estatal Esmeraldas. Chile: CEPAL.
174. Organización de las Naciones Unidas, (2016). Agenda 2030 para el Desarrollo Sostenible. Chile: CEPAL.
175. Organización de las Naciones Unidas (2016). Que nadie quede atrás: Acuerdos de gobernabilidad vinculados a losObjetivos de Desarrollo Sostenible. Perú: Mesa de concertación para la lucha contra la pobreza.
176. Organización Internacional del Trabajo, (2017). ODS: Manual de referencia Sindical sobre la Agenda 2030 para el Desarrollo Sostenible. Suiza: CEPAL
177. Orozco, G., (1997). La investigación en comunicación desde la perspectiva cualitativa. México: Instituto Mexicano para el Desarrollo Comunitario A.C.
178. Osorio (2004). *Patrón de reproducción del capital: una alternativa en el análisis económico.* Crítica de la economía vulgar: reproducción del capital y dependencia. México: Porrúa.
179. Ospina, S., (2004). Qualitative Research. Encyclopedia of Leadership. England, USA, India: SAGE Publications Inc.
180. Oxfam America, (2004). Impactos Económicos de la Minería y la Extracción Petrolera. Recuperado de http://www.oxfamamerica.org.
181. Oyangüren, P., (1981). Técnicas modernas para el dimensionado de minas metálicas subterráneas. Simposio sobre el uso industrial del subsuelo, España.
182. Oyangüren, P., De la Cuadra, Huerta, Grijalbo, (1984). Mecánica de rocas aplicada a la minería metálica subterránea. España: Instituto Geológico y Minero de España.
183. Pacheco, L., (2006). Propuesta de reaprovechamiento integral de agua de un proceso de una empresa minera utilizando sistemas biológicos anaeróbios. México: UNAM.
184. Pardo, A., San Martín, R., (2004). Análisis de datos en Psicología. España: Pirámide.
185. Parry, O., Mauthner, N., (2004). Whose data are they anyway? Practical, legal and ethical issues in archiving qualitative research data. New Delhi: BSA publications Ltd.
186. Pla Ortiz, F., (1994). Fundamentos del laboreo de minas. España: Fundación Gómez Pardo.
187. Plan Nacional de Desarrollo 2007-2012
188. Plan Nacional de Desarrollo 2013-2018.
189. Perevochtchikova, M., (2013). *La evaluación del impacto ambiental y la importancia de los indicadores ambientales*. Gestión y Política Pública. México: CIDE.
190. Pérez, G., (1994). Investigación cualitativa. Retos e interrogantes. España: Siglo XXI.
191. Pérez, J., (2010). La política ambiental en México: Gestión e instrumentos económicos. El Cotidiano 162. (92-97). Revista de la Realidad Mexicana. México: UAM.
192. Pérez-Carballo, J., (2013). Control de gestión empresarial, Texto y casos. España: ESIC Editorial.
193. Pigretti, E., (2004). Derecho Ambiental. Argentina: Ed. Gráfica Sur SRL.
194. PNUMA (2010). Avances y progresos científicos en nuestro cambiante medio ambiente. Programa de Naciones Unidas para el medio ambiente. 80 pp.
195. Polit, D., Hungler, B., (1991). Nursing Research. Principles and methods. México: Interamericana.

196. Polo, C., (2006). Los ejes centrales para el desarrollo de una minería sostenible. Chile: CEPAL
197. Popkewitz, T., (1988). Paradigma e ideología en investigación cualitativa. España: Mondarori.
198. Postic, M., Ketele, J., (1988). Observar las situaciones educativas. España: Narcea Ediciones.
199. Prefectura Carchi (2017),
200. Price, W., (1997). Guidelines and recommended methods for the prediction of metal leaching and acid rock drainage. Canadá: B.C. Ministry of Employment and Investment.
201. PROFEPA, (2015). Industria limpia. México: SEMARNAT, Recuperado en noviembre de 2019 de: https://propaem.edomex.gob.mx/certificacion_industrial
202. Ramos, A., (2004). Metodologías matriciales y evaluación para países en desarrollo: Matriz de Leopold y Método Mel-enel. Guatemala: USC.
203. Rau, J., (1980). Summarization of environmet impact. USA: McGrawHill.
204. Reidhead, W., (2017). Guía para el monitoreo integrado del Objetivo de Desarrollo Sostenible. Suiza: ONU-Agua.
205. Reyes, D., (2019). El proyecto sostenible como consecuencia al deterioro ambiental. México: UNAM.
206. Rodríguez, R., García, A., (2006). Los residuos minero-metalúrgicos en el medio ambiente. España: Isnsituto Geológico y Minero de España.
207. Rojas, I., (2011). Elementos para el diseño de técnicas de investigación: una propuesta de definiciones y procedimientos en la investigación científica. Tiempo de educar, vol. 12, núm. 24. México: UAEM.
208. Romo, D., (2011). Pemex, origen, evolución y perspectiva. México: PEMEX-IPN.
209. Romo, D., (2016). *Refinación de petróleo en México y persoectiva de la Reforma Energética*. Revista Latinoamericana de Economía, Vol 47, num 187, pp 139-164.
210. Rosa, (2005). Suelos contaminados por metales y metaloides: muestreo y alternativas para su remediación de minerales. México: Limusa.
211. Saavedra, E. y Sánchez, M., (2007). Minería y espacio en el Distrito minero Pachuca-Real del Monte en el siglo XIX.
212. Sabino, C., (1992). El proceso de investigación. Venezuela: Ed. Panapo.
213. Sáenz, K., Gorjón, F., Gonzalo, M., (2012). *Métodos cualitativos aplicados al Derecho.* Metodología para Investigaciones de alto impacto. México: DYKINSON S.L.
214. Sánchez, N., (2014). La Industria Minera en México a partir del TLCAN y sus implicaciones sobre el medio ambiente. México: UNAM.
215. Sancho (2001). Apuntes de Metodología de la investigación en turismo. España: OMT.
216. Santillana, M. (2006). La importancia de la actividad minera en la economía y la sociedad peruana. Naciones Unidas. Chile. Recuperado el 20 de enero de 2018 de http://repositorio.cepal.org/bitstream/handle/11362/6312/1/S0600580_es.pdf
217. Sautu, Boniolo, Dalle, Elbert, (2005). Manual de Metodología: Construcción del marco teórico, formulación de los objetivos y elección de la metodología. Argentina: CLACSO.
218. Schreier, M., (2004). Qualitative Content Analysis. The handbook of Qualitative Data Analysis, pp. 170-183. England: SAGE.
219. SE, (2017). Anuario estadístico de la minería Mexicana. Recuperado de 11 mayo de 2017 de: http://sgm.gob.mx/gobmex/productos/anuarios-historicos.html

220. SE, (2019). Directorio del Sector Minero. Recuperado en noviembre de 2019 de http://www.desi.economia.gob.mx/empresas/empresas3.asp?Clave=1194
221. SE-CGM, (2017). Comercio exterior del sector minero. Exportaciones. Recuperado el 11 de mayo de 2017 de: http://www.desi.economia.gob.mx/produccion/Exp1.asp
222. SE-DGM, (2018). Conseciones mineras. Recuperado 14 de diciembre de 2018 de: http://www.siam.economia.gob.mx/es/siam/Avisos
223. SE-SGM, (2017). Beneficio y transformación de minerales. Recuperado el 10 de mayo de 2017 de: http://www.sgm.gob.mx/Web/MuseoVirtual/Aplicaciones_geologicas/beneficio-y-transformacion-minerales.html.
224. SEMARNAT, (2002). Guía para presentación de Manifiesto de Impacto Ambiental. México: SE.
225. SEMARNAT, (2010). Manual de Sistemas de Manejo Ambiental. México. SE..
226. SEMARNAT, (2013). Impacto Ambiental. Recuperado el 5 de septiembre de 2017, de http://www.semarnat.gob.mx/temas/gestion-ambiental/impacto-ambiental-y-tipos/definicion-y-objetivo
227. SEMARNAT, (2014). Guía para conocer las etapas del proceso productivo para la pequeña minería. México: Secretaría de Economía.
228. SEMARNAT, (2016). *Guía para la elaboración de la Cédula de operación Anual*. Industria Metalúrgica. México: SEMARNAT
229. SG, (2013). Plan Nacional de Desarrollo 2013-2018. México: Gobierno de la República. Recuperado de: http://pnd.gob.mx/
230. SGM, (2017). Información geológica para la inversión minera. Coordinación General de Minería. México: Secretaría de Economía.
231. SGM, (2017). Beneficio y transformación de minerales. México: SE
232. SGM, (2018).
233. SGM, (2019).
234. SGM, (2018). Anuario Estadístico de la Minería Mexicana. México: SE.
235. SGM, (2018). Panorama Minero del Estado de Puebla. México: SE.
236. SGM, (2018). Panorama Minero del Estado de San Luis Potosí. México: SE.
237. SGM, (2018). Panorama Minero del Estado de Zacatecas. México: SE.
238. Sistema de Administración Minera (2016). México en el mundo. Dirección General de Minas. SE: México. Recuperado el 20 de enero de 2018 de: http://www.siam.economia.gob.mx/es/siam/mm_2016
239. Sistema de Administración Minera, http://www.siam.economia.gob.mx/
240. Sociedad Nacional de Minería, Petróleo y Energía, (2012). Informe de la SNMPE. Perú.
241. Subsecretaría de Minería, (2017). Manual del Inversionista en el sector Minero mexicano. Secretaría de Economía.
242. Subsecretaría de Minería (2017). Manual del Inversionista en el Sector Minero Mexicano. México: Secretaría de Economía.
243. Stake, R., (1995). The art of case study research. England, USA, India: SAGE Publications Inc.
244. Sutu, R., Boniolo, P., Dalle, P., y Elbert, R. (2005). Manual de Metodología. CLACSO: Argentina.
245. S&P Global Market Intelligence, (2017). World Exploration Trends. Chile: Grupo Editorial Editec.

246. Tancara, C., (1993). La investigación documental. Temas Sociales, Revista de Sociología, Num 17, pp 91, Bolivia.
247. Tandy, C., (1979). Industria y Paisaje. España: Instituto de Estudios de Admistración Local.
248. Torres, L., Miranda, M., (2018). El alcance institucional de los Obejtivos de Desarrollo Sostenible y la Agenda 2030 en México. Revista IAPEM, México
249. UNEP, (2000).
250. UNEP, (2001). Annual Report 2000. United Nations Environment Program.
251. UNEP, (2010). Avances y Progresos científicos en nuestro cambiante medio ambiente. Programa de naciones Unidas para el medio ambiente.
252. UNICEF (2015). España frente a los retos de la Agenda de Desarrollo Sostenible. España: UNICEF Comité español.
253. Viota, N., (2017). El derecho humano al medio ambiente en la Agenda 2030. España: UNESCO.
254. Wren, D., Bedeian, A., (2009). The evolution of management thought. Sixth edition, USA: WILEY.
255. Yacuzzi, E., (2005). El estudio de caso como metodología de investigación: teoría, mecanismos causales, validación. Philosofy, Universidad del CEMA.
256. Y*in, R., (1994). Case study Research. Design and Methods.* Canadá: SAGE.
257. Yin, R., (2010). Qualitative research from start to finish. USA: Guilford Press.
258. Yin, R., (2012). Application of case studies research. 3ra ed. Canadá: SAGE
259. Yin, R., (2013). Validez y generalización en futuras evaluaciones de casos de estudio. COSMOS corporation.
260. Volke, T., Velasco J., 2002. Tecnologías de remediación para suelos contaminados. México: INE-SEMARNAT.
261. Zeballos, O., (2016). *Sustentabilidad, Desarrollo Sustentable e Indicadores de Sustentabilidad para Agrosistemas.* Revista de Postgrado Scientiarvm: Perú.
262. http://www.latinomineria.com/wp-content/uploads/sites/2/2017/03/WET-Report_ES-DEF-1.pdf
263. https://www.abebooks.fr/Supervisor-Debe-Lester-bitel-John-Niewstrom/5735058919/bd
264. https://books.google.com.mx/books?id=06ptFLzbjjMC&printsec=frontcover&dq=gestion&hl=es&sa=X&ved=0ahUKEwj8kI7GhqngAhVHR60KHY2dC1Y4ChDoAQg9MAQ#v=onepage&q&f=false

Model zarządzania zrównoważonego zastosowany w przemyślu wydobywczym metali w Meksyku: Studium przypadku San Luis Potosi. (Streszczenie Rozprawy)

Rosa Elia Martínez Torres

Słowa kluczowe: *zarządzanie środowiskiem, rozwój zrównoważony, cele zrównoważonego rozwoju, meksykańskie ustawodawstwo górnicze, przemysł wydobywczy metali, kopalnie podziemne, Manifest Wpływu na Środowisko*

1. Znaczenie sektora przemysłu wydobywczego metali

Przemysł wydobywczy i metalurgiczny ma duży znaczenie dla gospodarki Meksyku, co jest zrozumiałe wobec faktu, iż geologię kraju charakteryzuje ogromne bogactwo złóż mineralnych , aż 70% terytorium kraju zawiera złoża mineralne, co wskazuje na istnienie dużego potencjału dla rozwoju górnictwa. Meksyk jest jednym z 12 głównych światowych producentów 20 minerałów, co w konsekwencji stawia go na pierwszym miejscu inwestycji w górnictwo w Ameryce Łacińskiej i czwartym miejscu w skali światowej (SE, 2019; SNL Metals & Mining, 2019; SGM, 2019).

Przemysł wydobywczy metali, stanowi 50,38% całkowitej produkcji górniczej kraju, z czego 10,25% stanowi produkcja srebra, wysoce reprezentatywna, gdyż od 2014 roku Meksyk zajmuje pierwsze miejsce na świecie w jego produkcji . Stan San Luis Potosi przysparza rocznie do 3,3% tej produkcji (SE, 2019; SGM, 2019).

Stan San Luis Potosi stanowi 3,12% terytorium meksykańskiego, jednakże 91% terytorium stanu kryje bogactwa mineralne (SGM, 2018). Zasoby mineralne oraz korzystne położenie geograficzne przyczyniają się do znaczenia gospodarczego Stanu, zajmującego siódme miejsce w kraju w produkcji srebra.

Poziom ochrony środowiska przyrodniczego, istotnego dla rozwoju zrównoważonego, w przypadku meksykańskiego przemysłu wydobywczego, stawia ten kraj w pozycji jednego z najbardziej zacofanych. Na Świecie około 1950 roku rozpoczęto prace mające na celu przeciwdziałanie szkodom środowiskowym. W 2016 roku ONZ w Agendzie 2030 przedstawiła Cele Zrównoważonego Rozwoju (SDG), sugerowane do wdrożenia w krajach członkowskich, aby zagwarantować dobrobyt przyszłym pokoleniom.

Pod wpływem globalnej presji, w Meksyku od 1985 roku zaczęły obowiązywać przepisy dotyczące górniczego zanieczyszczenia środowiska i na ich podstawie szacuje się dewastację środowiska. Kopalnie srebra w mają w tym przypadku istotne znaczenie (jako przykład) dla prowadzenia badań meksykańskiego górnictwie metali o stanie realizacji SDGs. Niniejsza rozprawa jest oparta na studium przypadku kopalni srebra w San Luis Potosí.

2. Oryginalność badań

Według badań Autorki na oryginalność pracy składają się jej następujące elementy, nie będące do tej pory przedmiotem prac naukowo-badawczych odnoszących się do Maksyku:

- Badania przedstawia sposób oceny praktyk środowiskowych, które gwarantują zasoby mineralne przyszłym pokoleniom w krajach rozwijających się, takich jak Meksyk, (UNEP, 2016).
- Stanowi propozycję oceny praktyk środowiskowych w Meksyku w odniesieniu do przemysłu wydobywczego metali
- Dysertacja przedstawia model pomiaru impaktu praktyk działania w środowisku przemysłu wydobywczego metali, koncentrując się na zasadach zrównoważonego rozwoju.
- Badanie proponuje zestaw rekomendacji promujących wdrożenie Modelu Zarządzania Zrównoważonego przemysłu wydobywczego metali, przedstawionego w rozprawie.
- W pracy przedstawiono propozycję wdrożeniową dla przemysłu wydobywczego metali (srebro), z możliwością rozszerzenia jej na cały przemysł metalowy w kraju.

3. Cele i hipotezy badawcze

Cel ogólny

Opracowanie propozycji Modelu Zarządzania Zrównoważonego , który pozwoliłby kierownictwu meksykańskiego przemysłu wydobywczego metali na wprowadzenie praktyk środowiskowych, zgodnych z uniwersalnymi zasadami zrównoważonego rozwoju (UNEP, 2010), a także z przepisami (SEMARNAT, 2002).

Cele szczegółowe

- Przeprowadzenie szczegółowej analizy podstaw zrównoważonego rozwoju i przepisów prawnych odnoszących się do meksykańskiego przemysłu wydobywczego.
- Analiza praktyk środowiskowych stosowanych w przemyśle wydobywczym metali w Meksyku, ze szczególnym uwzględnieniem przykładowej, podziemnej kopalni srebra.
- Opracowanie modelu oceny praktyk środowiskowych w odniesieniu do zgodności z zasadami zrównoważonego rozwoju.
- Zaproponowanie najlepszych praktyk w celu zagwarantowania zrównoważonej eksploatacji zasobów minerałów metalurgicznych w San Luis Potosi i określenie zaleceń dla przemysłu wydobywczego metali w Meksyku.

Hipotezy

- Badania naukowe związane ze środowiskowymi praktykami wydobywczymi skupiały się głównie na szkodach ekologicznych, dlatego ich wyniki nie są zgodne z Zasadami Zarządzania Zrównoważonym Wydobyciem Metali w Meksyku.
- Określenie praktyk środowiskowych zgodnych z Zasadami Zrównoważonego Rozwoju w Meksyku będzie możliwe dzięki badaniu przemysłu wydobywczego metali.
- Zdefiniowanie najlepszych praktyk środowiskowych oznacza wdrożenie modelu zarzadzania zrównoważonego i jego walidację w terenie, w przemyśle wydobywczym metali, w szczególności zasobów minerałów metalicznych w San Luis Potosi (Srebro). Pozwali to na rozszerzenie zestawu rekomendacji na meksykański przemysł wydobywczy metali.

4. Metodologia badań

Badania przeprowadzono w latach 2017-2019 obejmując badania zrównoważonego rozwoju w ramach dyscypliny naukowej zarządzanie w obszarze środowiskowym. Informacje bibliograficzne i opis hipotez pozwoliły na ich weryfikację metodą studium przypadku. Zastosowano podejście jakościowe i konstruktywistyczny paradygmat interpretacyjny oraz analizę opisową uzyskanych wyników; do zbierania danych wykorzystano przyrządy pomiarowe skonstruowane na potrzeby tego badania: przewodnik obserwacji, wykaz weryfikacji oraz wywiady nieformalne.

Metoda Simple Holistic Case Study jest odpowiednia do analizy różnych podmiotów w tym samym miejscu lub jednostce, w przypadku gdy studium przypadku daje możliwość weryfikacji, stworzenia lub opisania nowych teorii, które w tym konkretnym przypadku odnoszą się do weryfikacja hipotezy (Yin, 1994: 2002). Do analizy wybrano kopalnię minerałów metalicznych, produkującą srebro (Ag-Au-Pb-Zn). Jednostka znajduje się w stanie San Luis Potosi, blisko granicy z Zacatecas. Dobór obiektu badawczego był arbitralny (Hernandez, 2014).

Badanie przeprowadzono systematycznie, traktując literaturę przedmiotu jako bazę wyjściową, pozwalającą na zbudowanie modelu do oceny praktyk środowiskowych obiektu , obejmujących oprócz aspektów środowiskowych także legislacyjne. Model opracowany w rozprawie został zbudowany i oceniony teoretycznie i praktycznie poprzez studium przypadku. Jego podstawą są cztery Zasady Zrównoważonego Rozwoju zaczerpnięte z Agendy 2030 (ONZ, 2016) oraz 15 Parametrów Legislacyjnych zaczerpniętych z Manifestu Oddziaływania na Środowisko (SEMARNAT, 2002), tj. oficjalnego dokumentu do obserwacji i oceny aspektów środowiskowych obowiązujący w Meksyku.

5. Główne wyniki

Przeprowadzone badania, zastosowanie modelu oraz prace terenowe w analizowanym obiekcie badawczym w San Luis Potosi pozwoliły zweryfikować cele i postawioną hipotezę. Prace terenowe prowadzono systematycznie metodą studium przypadku. Kopalnia srebra w San Luis Potosi pozwoliła na dokonanie obserwacji, które umożliwiają interpretację i opis praktyk, w odniesieniu do wszystkich Zasad Zrównoważonego Rozwoju oraz Parametrów Legislacyjnych. Najważniejsze z wyników to:

- Badanie przedstawia propozycję oceny praktyk środowiskowych w sektorze wydobycia surowców metalicznych w Meksyku przy zastosowaniu Modelu Zarządzania Zrównoważonego.
- Zastosowanie Modelu dostarcza spostrzeżeń w zakresie sposobu, w jaki Zasady Zrównoważonego Rozwoju są uwzględniane w strategii Zarządzania Środowiskowego.
- W zakresie zasad zrównoważonego rozwoju i parametrów prawnych, zasadnicze spostrzeżenia są następujące:

→ Parametry legislacyjne w pełni zostały uwzględnione w jednej z zasad zrównoważonego rozwoju: *życie ekosystemów lądowych*, co potwierdza hipotezę o meksykańskim prawodawstwie dotyczącym górnictwa, iż uwzględnia ono jedynie wpływ na środowisko, nie biorąc pod uwagę zapewnienia zasobów w dla przyszłego społeczeństwa , a wymiar społeczny i środowiskowy, zawarte w zasadach *Odpowiedzialnej Produkcji i Konsumpcji* są w niewielkim stopniu uwzględniane w aktach normatywnych Meksyku.

→ W odniesieniu do zasad *Zrównoważonych Miast i Społeczności*, kopalnia srebra ogranicza swoje praktyki do definicji programów Odpowiedzialności Społecznej, prowadzonych bez nakładowo, jedynie w celu minimalizacji problemów społecznych działalności.

→ Zastosowanie proponowanego modelu potwierdza hipotezy: obecne badania w sektorze górniczym koncentrują się na szkodach ekologicznych, w wyniku czego przemysł metalowy w Meksyku stosują się do norm tylko celem uzyskania pozwolenia na eksploatację *(Hipoteza 1).*

→ Przypuszcza się, że dzięki prowadzonym badaniom w przemyśle wydobywczym metali, praktyki środowiskowe będą w przyszłości zgodne z Zasadami Zrównoważonego Rozwoju *(Hipoteza 2).*

→ Aby osiągnąć stosowanie dobrych praktyk, konieczne jest wdrożenie Modelu Zrównoważonego Zarządzania w przemyśle wydobywczym metali, w szczególności w zakładach metalowych San Luis Potosi *(Hipoteza 3).*

6. Rekomendacje i powtarzalność

Badania, prowadzone podczas wdrożenie Modelu Zarządzania Zrównoważonego , wykazały, w jaki sposób rzeczywiste praktyki środowiskowe w wybranym obiekcie badawczym pokrywają się z globalnymi sugestiami, zgodnie z propozycją ONZ w Agendzie 2030. Badanie opisuje ponadto problemy działań mających na celu promowanie lepszych praktyk środowiskowych ,charakterystyczne dla górnictwa. Rekomendacje zostały przedstawione zgodnie z Zasadami Zrównoważonego Rozwoju tak, aby każde z proponowanych działań było wykonalne, wskazano najwłaściwsze instytucje do ich realizacji, jak też obowiązki wynikające z postanowień prawa.

Model zaprojektowany dla przemysłu wydobywczego metali, który został wdrożony w San Luis Potosi, może być zastosowany także w innych jednostkach przemysłu metalowego w Meksyku, gdyż parametry prawne są takie same dla całego sektora. Model stanowi uzupełnienie strategii Zarządzania Organizacją opartej na przestrzeganiu przepisów ochrony środowiska na poziomie międzynarodowym i krajowym, wskazując, czy obecne praktyki środowiskowe zapewniają osiągnięcie celów środowiskowych, czy też należy je przeanalizować i zmienić, aby były skuteczne .

7. Wnioski

Przedstawione wnioski stanowią podsumowanie badań, przeprowadzonych w wybranym obiekcie badawczym, z zastosowaniem rygoru metodologicznego, który przy użyciu studium przypadku analizuje praktyki środowiskowe i jako narzędzia pozyskiwania danych stosuje obserwację i analizy jakościowe. Praca zawiera także szczegółową analizę literatury przedmiotu. Postawione hipotezy i szczegółowe cele badania zostały zweryfikowane na podstawie miernika Zrównoważonych Zasad i Parametrów Legislacyjnych. Praktyczna i teoretyczna ewaluacja Modelu Zarządzania Zrównoważonego potwierdziła cele rozprawy.

Przedstawiono oryginalną propozycję Modelu dla przemysłu wydobycia metali w Meksyku. Wskazuje on ogólne wymagania, nie naruszając przy tym zobowiązań prawnych. Model jest elastyczny, aktualizowany i prezentuje innowację w zakresie dokumentacji, dzięki czemu w części operacyjnej może być wkomponowany w zarządzanie środowiskowe firm.

Uwaga dla czytelnika: Referencje użyte w streszczeniu są podane w Bibliografii rozprawy.

Sustainable Management Model applied to the Metallic Mining Industry of Mexico: Case Study in San Luis Potosí. (Dissertation abstract)

Rosa Elia Martínez Torres

Keywords: *environmental management, sustainable development, sustainable development goals, Mexican mining legislation, metal mining industry, underground mines, Environmental Impact Manifesto*

1. Relevance of the metallic mining industrial sector

The Mining-metallurgical Industry has a strong economic contribution in Mexico and, geologically, the geography stands out for its mineral wealth, considering that the 70% of the national territory contains mineral deposits, so there is a high potential for mining developments; this among the 12 main producers worldwide of 20 minerals and places it as the first destination for investment in mining exploration in Latin America and the 4th in the world (SE, 2019; SNL Metals & Mining, 2019; SGM, 2019).

Metallic Mining Industry, represents the 50.38% of the total of mining production in the country; collaborating with the 10.25% of this total Silver production, and is representative since it manages to occupy the 1st place in worldwide since 2014. The state of San Luis Potosi contributes 3.3 % per year (SE, 2019; SGM, 2019).

San Luis Potosi represents 3.12% of the mexican territory and in turn it has 91% of mineralized soil (SGM, 2018); the mineralization and geographic location promotes it as an economically active state; it occupies the seventh place in silver production in the country.

About caring for the environment, centralized around the mining industry in Mexico, there are facts that place the country as one of the most backward in this context. The environment in the world begins to be evaluated to counteract the damage, around 1950; Recently the UN (2016), through the *Agenda 2030*, presents the Sustainable Development Objectives (SDG) suggested to be implemented in the member countries to guarantee the well-being of future generations.

Mexican mining environmental Laws began until 1985 due to global pressures, for which a severe devastation of the environment is estimated. Considering these facts, the importance and relevance of carrying out a research within the Mexican mining metal sector is visualized, which provides information about the implementation of these SDGs. This study is supported by a case study developed in an underground silver mine in the state of San Luis Potosí.

2. Originality

According to the author, the originality of the thesis consists of:

- The research presents a way of evaluating the environmental practices that guarantee the mineral resource for future generations in developing countries like Mexico through Sustainability foundations (UNEP, 2016).
- It represents a proposal to evaluate the environmental practices in Mexico oriented to the mining sector of metallic resources.
- This thesis presents a model to measure the environmental practices of the Metallic Mining Industry focusing on Sustainable fundamentals.
- The research proposes a set of recommendations to promote the implementation of the Sustainable Model in the Metallic Mining Industry.
- The thesis presents an implementation proposal within the Metallic Mining Industry (silver), with the possibility of extending it to the metallic Industry and another entities in the country.

3. Research Objectives and hypothesis

General Objective

Propose Sustainable Model that allows the Metallic Mining Industry of Mexico from its Management, to carry out environmental practices that align with universal principles of Sustainability (UNEP, 2010) in addition to compliance with legislation (SEMARNAT, 2002).

Specific Objectives

- Carry out literary analyzes to relate the Sustainable foundation and the Legislative foundation of mexican Mining Industry.
- Analyze the environmental practices carried out in the Metallic Mining Industry in Mexico, considering an underground silver mine.
- Develop a Model to evaluate environmental practices in reference to compliance with Sustainable Principles.
- Propose best practices to guarantee the metallic mineral resource in San Luis Potosi and define recommendations for the Metallic Mining Industry in Mexico.

Hypothesis

- Research studies related to environmental mining practices have focused mainly on the ecological damage, therefore, their results are not aligned with Sustainable Principles in the Metallic Mining Industry of Mexico.
- The determination of the environmental practices aligned with Sustainable Principles in Mexico will be possible through an investigation of the Metallic Mining Industry.
- Defining best environmental practices, implies the implementation of a Sustainable Model and its validation in the field in the Metallic Mining Industry, particularly the metallic mineral resource in San Luis Potosi (Silver). It is allow to extend a set of recommendation for mexican Metallic Mining Industry.

4. **Research Methodology**

The research was conducted between the years 2017-2019. It contemplates a *research line* of Sustainability inside a *scientific discipline* of Management in the Environmental area. The literary information and hypothesis description, allows to be validated by a Case Study method. It presents through a Qualitative focus and a Constructivist Interpretative paradigm, a Descriptive Analysis of the obtained results; the data collection was carried out with the use of measuring instruments constructed for this investigation: guide of observations, list of verification and informal interviews.

The Simple Holistic Case Study method is appropriate to analyze different subjects in the same place or analysis unit, also with the evidence that the case study obtains, is possible to verify, generate or describe new theories, that in this particular case it refer to the hypothesis verification (Yin, 1994: 2002). The selected analysis unit is a metallic mineral underground mine that produces Silver. The unit is located in the state of San Luis Potosi, close to the border with Zacatecas. It is belonging to the Trend of mineralization Ag-Au-Pb-Zn. The sample selection was for convenience (Hernandez, 2014).

The development is performed systematically, considering the literary basis as a starting point allowing to formalize a model to evaluate from the environmental practices of a unit, sustainable and legislative aspects. The model is constructed and validated theoretically and practically through the Case Study, It contains the foundations of four Sustainable Principles taken from the Agenda 2030 (UN, 2016) and 15 Legislative Parameters taken from the Environmental Impact Manifest (SEMARNAT, 2002), that is official document to follow and evaluate the environmental aspects in Mexico.

5. **Main Results**

The conducted research, the application of the model, and the field work in the unit of analysis in San Luis Potosi allowed to verify the goals and the hypothesis. The field work was made systematically following the case study method. The silver mine in SLP, offers observations that allows interpreting and descripting the practices that are carried out according to each Sustainable Principle and in reference to the Legislative Parameters. Some of the results are:

- The research presents a proposal to evaluate the environmental practices in Mexico oriented to the mining sector of metallic resources through a validated Sustainable Management Model.
- The implementation of the Model, provided observations on the way in which Sustainable Principles are considered in the Environmental Management strategy.
- About Sustainable Principles and Legislative Parameters, important observations are:

- → The legislative parameters in full, were noted in one Sustainable Principle: *life of Terrestrial Ecosystems*, that in first instance proves the hypothesis about the Mexican legislation in mining matter, it validates only ecological impacts, not minding the resource guarantee in the close future, that in relation with the *Responsible Production and Consumption* principle meaning that the social and environmental dimension, are far from being considered for Mexico's normativity.
- → In reference with the principle of *Sustainable Cities and Communities*, the silver mine presents their practices around the definition of Social Responsibility programs, which take place without funding, just to operate with the minimum of social problems.
- → In its implementation, the model proposed confirms the hypothesis of the research: the current studies in the mining sector, are focused on the ecological damage, due to that, the metallic units in Mexico, follow the normative just for their operating permission *(Hypothesis 1).*
- → It is possible that through an investigation in the metallic mining industry, the environmental practices line up to the Sustainable Principles (*Hypothesis 2).*
- → To define best practices, it is necessary to implement a Sustainable Management validated Model in the field in the Metallic Mining Industry, particularly in the San Luis Potosi metal units *(Hypothesis 3).*

6. Recommendations and replicability

The research, through the implementation of the Sustainable Management Model, described how the actual environment practices in the selected unit, line up with the global suggestions, as the UN proposed through the Agenda 2030; It describes in addition, problems of functionality in the mining industry, which were taken into account to define a series of actions aimed at promoting better environmental practices in this sector. The recommendations were organized according to the Sustainable Principles to give viability to each of the proposed actions, the most appropriate institutions were identified to support their implementation, also complying with the obligations of law.

The Model designed for the Metallic Mining Industry and that was implemented in San Luis Potosi, can be replicated in other metallic units in Mexico, considering it is extended activity in the country and, that the Legislative Parameters are the same for the entire sector. It represents a complement to the strategy from the Organizational Management based on compliance with environmental regulations at the international and national level, managing to show if the current environmental practices provide achievements in favor of the environment or, reconsider and rewrite them so that they are effective.

7. Conclusions

The conclusions described, frame a summary of everything observed in the unit of analysis through methodological rigor, which, using a Case Study, analyze environmental practices through the observation and qualitative descriptions in the data collection instruments. The hypotheses and the course of the specific objectives of the research were verified on the basis of the measure of Sustainable Principles and Legislative Parameters; in the practical and theoretical validation the proposal of the Sustainable Management Model, achieving the general objective.

A literary debate is also generated in which, for the purposes of this investigation, a triangulated description is presented, which is also considered, a conceptual contribution. For the Metallic Mining Industry in Mexico, a valid and original proposal is presented. It is considered a Sustainable Management Model that measure global requirements without missing its legislative obligations. It is flexible, updated and presents documentary innovation, then it is possible, in its operational part, being inserted in the environmental management of companies.

Note to the reader: *The references used in the abstract are listed in the bibliography of the thesis.*

Statement of the work supervisor

Statement of the work supervisor I certify that this work has been prepared under my supervision and I state that she meets the conditions to be presented in the procedure for awarding the doctoral degree in social sciences in the field of management and quality science.

Date: September, 2021

dr hab.inż. Mariusz Bednarek prof. WSB Warszawa

The author's statement

Author's statement Being aware of my legal responsibility, I declare that this doctoral dissertation was written by me myself and does not contain content obtained inconsistently with applicable regulations.

I also declare that the presented work has not previously been the subject of procedures related to obtaining a professional or scientific title at a university.

Moreover, I declare that this version of the doctoral dissertation is identical to the attached electronic version.

Date: September, 2021 Rosa Elia Martínez Torres

Author's consent

Author's consent I consent / I do not consent to the dissemination of my doctoral dissertation for scientific and research purposes.

Date: September, 2021 Rosa Elia Martínez Torres