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In the first article we present, *Uncontrolled urbanization south of Zapopan, Jalisco, Mexico: Adaptation measures to infringe the effects of climate change* by Salas-Tafoya, José Manuel, Valenzuela-González, Elizabeth, Porras-Zárate, Iván and Hernández-Valenzuela, José de Jesús Nicolás, with adscription in Universidad de Guadalajara, as the next article we present, *Pressure drop prediction by a polynomial model for two-phase flow in vertical oil wells* by Hernández-Santos, Abisai, Escobedo-Trujillo, Beatris Adriana, Alaffita-Hernández, Francisco Alejandro and Colorado-Garrido, Darío, with adscription in Centro de Investigación en Recursos Energéticos y Sustentables and Universidad Veracruzana, as the next article we present, *Statistical representation of university management as a means for sustainable development in connection with the productive sector* by Hernández-Peralta, Alejandro De Jesús, Antonio-Vidaña, Paula Rosalinda, Alcudia-Chagala, Lorena and Rojas-Patiño, Nancy, with adscription in National Technological Institute of Mexico, as the last article we present, *Protected Natural Areas: A literary analysis of the Decrees of the Cerro de San Juan Biosphere State Reserve in Nayarit* by Gómez-Pintado, Rocío, Zepeda-Martínez, Gabriel, Enciso-Arámbula, Rosalva and Soto-Ceja, Edel, with adscription in Universidad Autónoma de Nayarit.

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Uncontrolled urbanization south of Zapopan, Jalisco, Mexico: Adaptation measures to infringe the effects of climate change

Urbanización descontrolada sur de Zapopan, Jalisco, México: Medidas de adaptación para vulnerar los efectos del cambio climático

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Abstract

The La Primavera Forest System and El Bajío Zone have suffered uncontrolled urban growth, which causes a decrease in permeable soil for river waters. This has caused flooding in surrounding neighborhoods for more than five years, and affected the properties and furniture of the inhabitants of those neighborhoods. Currently this system is characterized as a territory contributing to climate change. This contribution is related to the economic sector, since the negative anthropogenic externalities generated by uncontrolled urban growth are due to the existence of limited urban-enviromental legislation, and also because these are no applied completely and sufficiently. For this reason, the following work is proposed, the objective of which is to "Propose adaptation measures for the La Primavera Forest System and the Bajío Zone, through the analysis of the floods that neighboring colonies have suffered, which will allow improving the quality of life of the inhabitants and the conditions of the territory.

Uncontrolled urbanization south of Zapopan, Jalisco, Mexico: Adaptation measures to infringe the effects of climate change.

Objective	Methodology	Contribution
To propose adaptation measures for the Bosque la Primavera System and the El Bajio Zone, through the analysis of political, urban and environmental controversies, which allows the surrounding neighborhoods to adapt to the system, in turn, improve the quality of life of the inhabitants and the conditions of the territory.	The research is qualitative, with respect to the research strategy, the study is situated from the interpretive perspective, through the case study strategy. As for the type of case study, this corresponds to the intrinsic one, remember that it is one that is not sought by the researcher.	Answer why the neighborhoods surrounding the La Primavera Forest System and the El Bajio Zone are flooded.

Uncontrolled urbanization, climate change and adaptation

Resumen

El Sistema Bosque la Primavera y Zona El Bajío ha sufrido un crecimiento urbano descontrolado, lo cual ocasiona disminución de suelo permeable para las aguas fluviales. Esto ha causado durante más de cinco años inundaciones en colonias aledañas, y afectado inmuebles y mobiliario de los habitantes de esas colonias. Actualmente este sistema se caracteriza como un territorio contribuyente al cambio climatico. Esta contribución se relaciona con el sector económico, ya que las externalidades antropogénicas negativas que genera el crecimiento urbano descontrolado se deben a la existencia de legislación urbanoambiental limitada, además, porque estas no se aplican de manera total y suficiente. Por tal motivo, se propone el siguiente trabajo cuyo objetivo es "Plantear medidas de adaptación para el Sistema Bosque la Primavera y Zona El Bajío, a través del análisis de las inundaciones que han sufrido colonias aledañas a este, que permita mejorar la calidad de vida de los habitantes y las condiciones del territorio".

Urbanización descontrolada sur de Zapopan, Jalisco, México: Medidas de adaptación para vulnerar los efectos del cambio climático

Objetivo	Metodología	Contribución
Plantear medidas de adaptación para el Sistema Bosque la Primavera y Zona El Bajío, a través del análisis de las controversias políticas, urbanas y ambientales, que perita adaptar las colonias aledañas al sistema, a su vez, mejorar la calidad de vida de los habitantes y las condiciones del territorio.	La investigación es de tipo cualitativa, respecto a la estrategia de investigación, el estudio se sitúa desde la perspectiva interpretativa, a través de la estrategia de estudio de caso. En cuanto al tipo de estudio de caso, este corresponde al intrínseco, recordemos que es aquel que no es buscado por el investigador.	Responder por qué se inundan las colonias aledañas al Sistema Bosque la Primavera y Zona El Bajío.

Urbanización descontrolada, cambio climático y medidas de adaptación

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Introduction

The La Primavera Forest System and El Bajío Zone have suffered uncontrolled urban growth, which causes a decrease in permeable soil for river waters. This has caused flooding in surrounding neighborhoods for more than five years, and affected the properties and furniture of the inhabitants of those neighborhoods. Currently this system is characterized as a territory contributing to climate change. This contribution is related to the economic sector, since the negative anthropogenic externalities that generate uncontrolled urban growth are due to the existence of limited urban-environmental legislation, and also because these are not applied in a complete and sufficient manner. For this reason, the following work is proposed, the objective of which is to "Propose adaptation for the La Primavera Forest System and the El Bajío Zone, through the analysis of measurements of the floods that neighboring colonies have suffered, which allow improving the quality of life. of the inhabitants and the conditions of the territory."

This proposal will make it possible to improve the vitality of the inhabitants, in turn, increase the quality of life; Together, contribute to the eradication of poverty and the sustainability of life, by increasing psychological, health, labor stability, sense of belonging and social cohesion, which together make governance possible. The research is qualitative, with respect to the research strategy, the study is situated from the interpretive perspective, through the case study strategy. As for the type of case study, this corresponds to the intrinsic one, remember that it is one that is not sought by the researcher.

Statement of the problem

Problem Urban growth in the lower area of the Bosque la Primavera and El Bajio area, identified in this work as the Bosque la Primavera System and the El Bajío Area, generates flooding. In 2021 Milenio published "This year, for the third time the El Seco stream overflowed in Zapopan after the storm that occurred on Saturday afternoon, affecting the neighborhoods Lomas de la Primavera, Miramar, Villas de la Primavera, Arenales Tapatíos, Colinas de la Primavera, El Briseño and Jardines Tapatíos" (Ruiz, 09/05/2021).

In 2022 Telediario reported "The residents of the Miramar neighborhood in Zapopan describe what they are experiencing as a nightmare, because after the rains that have been recorded in recent days and which have caused the El Seco stream to overflow, it has made it difficult for them their daily life" (Álvarez, 07/11/2022). For its part, the Jalisco State Human Rights Commission announced in its document "Environmental problems in Jalisco August 29, 2022" "In the metropolitan area of Guadalajara, the rains damaged 50 houses in Tlajomulco de Zúñiga; in addition to the west of Guadalajara and the center and south of Zapopan" In short, for two consecutive years the south-eastern area of Zapopan has been flooded, this can be considered an environmental problem.

Research question

The question that guides this work is: Why are the colonies surrounding the Bosque la Primavera System and Zona El Bajío flooded?

Hypothesis

To answer the research question, the following hypothesis is proposed, which has emerged from the preliminary analysis of the territory and the political, urban and environmental controversies. The neighborhoods surrounding the Bosque la Primavera System and Zona El Bajío are flooded due to the uncontrolled urban growth that their territory has suffered, which begins with the deforestation of the forests and concludes with the increase in concrete and a decrease in permeable surface for river waters. . Added to this situation is the insufficiency of current environmental legislation, in turn, the lack of application of the existing one.

General and specific objective

The general objective through which the research question will be answered is to "Propose adaptation measures for the La Primavera Forest System and the El Bajío Zone, through the analysis of political, urban and environmental controversies, which allow the adaptation of the surrounding colonies. to the system, in turn, improve the quality of life of the inhabitants and the conditions of the territory." To achieve the general objective, the specific objectives are set:

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1. Analysis of the floods that occurred in the Bosque la Primavera System and the El Bajío Zone.
2. Establish the political, urban and environmental controversies that are related to the climate impact that occurs in the La Primavera Forest System and the El Bajío Zone.
3. Establish the relationship between quality of life and conditions of the territory.

Theoretical fundament

Climate change

Climate change is a worldwide phenomenon that brings with it global variation in climate, whose persistence is for long periods of time. This modification is due to the direct action of man who alters the composition of the global atmosphere, due to the excessive emission of greenhouse gases, which are produced through the use of electrical energy, excessive consumption of fossil fuels, pollution of urban areas, etc. Its effect is observed in the increase in temperature, heat waves, a greater number of hurricanes and tropical storms, the drying of rivers, etc.

Box 1

Figure 1
Overall Effect: Global warming
Source: Google:2023

Box 2

Figure 2
Local Effect: Air pollution: Western area of the Guadalajara Metropolitan Area

Box 3

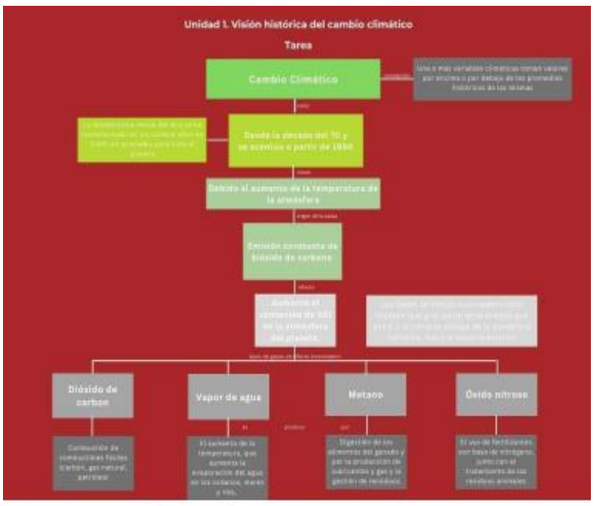

Figure 3
Historical view of climate change
Source: Own construction

Methodology

Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Climate change is a phenomenon caused by several factors, in which the complexity of their interrelationships stands out. Likewise, its effects are systemic in nature. In this sense, the starting point of my interpretation of climate change is built from difference and not identity.

Therefore, we start from the condition before climate change and contrast it with the current situation. From there we establish what current situation climate change communicates to us?

I will focus my interpretation on the local, I clarify, it is not reality, since everyone builds their own, mine is an interpretation. So what does climate change tell us locally? We look at only a part of the environment and there we observe that urbanization in the last 7 decades has contributed to the increase in the emission of carbon dioxide, which has increased in the last 40 years, through a diffuse and expansive urbanization that generates greater travel distances, consequently, an increase in gasoline or diesel means of transportation, both public and private, with the complacency of the corresponding authorities.

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The developers do not agree with this, they continue to exploit an architectural "model" of designing buildings for residential and commercial use that lacks sustainability, which only causes greater consumption of non-renewable energy (at least in our country) such as electricity, to quell the high temperatures that are reached inside houses and residential and office apartments, lacking conditions that violate the quality of life, such as lighting, ventilation, etc. Regarding the effects on health, family coexistence, learning at home, etc., we better not even interpret it.

The research is qualitative; this type, following Katayama (2014), allows knowledge of complex phenomena, focuses on typically human phenomena, and allows the study of the fields where deceptive behaviors occur. Therefore, considering that it is a social investigation, the present study is framed in the conceptual-inductive model or system. The research process in this model is focused, according to Katayama (2014), on the following dimensions:

1. Beginning of the observation of social facts
2. Obtaining and classifying data until saturation is achieved
3. Formulation of concepts and hypotheses
4. Systematization and structuring of concepts and hypotheses for the construction of theories.

In this type of research, the phenomena are observed in situ, through two moments: i) exploration, inspection and description and explanation; ii) words, non-numerical data, objects of exploration; and numerical data are words, texts and images. And from these, categories and concepts are established. Katayama (2014).

Regarding the research strategy, the study is situated from the interpretive perspective, through the case study strategy. The nature of this strategy is the study of a particular phenomenon. This is understood as a specific theoretical construction pre-established by a scientific community.

As for the type of case study, this corresponds to the intrinsic one, remember that it is one that is not sought by the researcher.

The case is not studied because it represents other cases, or because it illustrates some feature, but because the case is interesting in itself.

Political-environmental controversies

Crossroads between environmental policy and political environment

The Mexican government finds itself in a dilemma between sustainability and a higher rate of acceptance by the population. In the last three decades, Mexico has signed international agreements to contribute to the fight against climate change. If we draw a timeline from 1992, the United Nations Framework Convention on Climate Change, COP3 held in Kyoto in 1997, COP13 in Bali in 2007, COP15 in Copenhagen in 2009, COP16 in Cancún in 2010, COP11 in Durban in 2011, COP18 in Doha in 2012, COP19 in Warsaw in 2013, COP20 in Lima in 2014, COP21 in Paris in 2015, COP22 in Marrakech in 2016, the COP23 in Bonn in 2017, COP24 in Katowice in 2018, COP25 in Chile in Madrid and COP26 in Glasgow in 2021 and COP27 in Egypt in 2022. On the other hand, in the national political and economic sphere, the beginning of the construction of the Texcoco Airport in 2015, the beginning of the implementation of the Mayan Train in December 2018 and the inauguration of the construction of the Dos Bocas refinery, in Tabasco, in August 2019. In the timeline, two representations can be seen, the first, 26 years of international consensus on policies and economies against climate change, in the second, eight years of national dissent caused by economic politicking.

The United Nations Conference on Environment and Development in Rio de Janeiro in 1992 is recognized as the formal start on climate change. The United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, reflected the international consensus when addressing the problem of climate change. During its celebration, the United Nations Framework Convention on Climate Change (UNFCCC) was created, which was initially signed by 166 countries and finally came into force on March 21, 1994. Currently, it has been ratified by 197 countries. (Iberdrola, 2023).

During the 16 COPs, 5 agreements stand out (Iberdrola, 2023):

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1. Limit the increase in global temperature to below 2º C compared to the level of the pre-industrial 404 era.
2. National climate contributions that contribute to the defined long-term objective.
3. Financing from developed countries to developing countries for investment in sustainable and socially responsible assets such as renewable energies.
4. Technology transfer to developing countries to achieve the 2ºC objective.
5. Adaptation and mitigation to climate change through planning and implementation of measures.

In conclusion, the agreements established from the United Nations Framework Convention on Climate Change give shape to a pact to build a global strategy to combat climate change.

Participation of Mexico in cooperation agreements

Mexico, two faces with different makeup in the face of climate change: towards the outside, a makeup of commitment; towards the interior, a makeup of oblivion. The Mexican government presents two different faces regarding Climate Change.

Towards the outside world, it declares its commitment to combating Climate Change, "The Government of the Republic is committed to respecting the environment and promoting the generation of clean energy" (Government of Mexico, 2016). Inside "At the beginning of the six-year term, López Obrador set out to increase oil production and "rescue" Pemex —the parastatal's emissions have doubled since then— " (Cullell, 2022). In summary "Mexico has surprised the COP 27. After building a huge refinery and paralyzing private investment in renewable energy, the Mexican Government wanted to show the world that it takes the environment seriously" — (Cullell, 2022).

The Government of Mexico, a lot of written commitment. In 1992, Mexico signs the United Nations Framework Convention on Climate Change (UNFCCC). The Convention was ratified before the UN in 1993 and entered into force on March 21, 1994.

It established a framework for action whose ultimate objective is to "Achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference in the climate system (Government of Mexico, 2018). As part of the UNFCCC agreements, it was established to hold the Conference of the Parties (COP) annually, a meeting in which negotiations are carried out to advance towards compliance with the objectives of the UNFCCC. The first COP was held in 1995 in Berlin, Germany (Government of Mexico, 2018). In short, it seems that Mexico actively and regularly participates in the international context regarding Climate Change policies.

Mexico active and regular participation in meeting the objectives of the United Nations Framework Convention on Climate Change (UNFCCC)? As part of the UNFCCC agreements, it was established to hold the Conference of the Parties (COP) annually.

The first COP was held in 1995 in Berlin, Germany and since then Mexico has participated. On June 9, 1998, Mexico signed the Kyoto Protocol. Although it was approved in December 1997, it came into force until February 16, 2005 (Government of Mexico, 2018). This legally binding instrument commits industrialized countries to reduce emissions of greenhouse gases: carbon dioxide (CO2), methane gas (CH4) and nitrous oxide (N2O), in addition to three fluorinated industrial gases: Hydrofluorocarbons (HFC's), Perfluorocarbons (PFC) and Sulfur Hexafluoride (SF6), on average, by 5.2% in its first commitment period (2008-2012).

Finally, in 2015 COP 21 was held in Paris, France, where 195 nations made commitments against climate change and in favor of the environment and sustainable development.

The main agreements are about the reduction of greenhouse gas (GHG) emissions. In it the nations, both developed and developing, to work together in an ambitious, progressively equitable and transparent manner to keep the global temperature below 1.5 ºC. At the end of the day, no one would doubt the efforts resulting in the Paris Agreement, however, it would be appropriate to ask ourselves: What has happened in Mexico?

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Environmental controversies

The then president Enrique Peña Nieto relaunched the Airport project in Texcoco in 2014; In December 2018, the cancellation of the construction of the New International Airport of Mexico City (NAICM) was decided. After the results of the citizen consultation were published in which 70% of just over a million voters chose to cancel the airport in Texcoco and instead recondition the AICM and the Santa Lucía air base" (Van Bedolla, 25 /02/2021) the Government of Mexico decided to cancel the construction. On April 26, 2019, the Ministry of Communications and Transportation published "The Airport in Texcoco should never have been approved, much less started. It was a very serious error, the cancellation of which prevented a major ecological disaster, a severe demographic explosion in the Eastern Zone of the Valley of Mexico…" (Government of Mexico, 04/26/2019).

In this regard, Greenpeace considered at the time that the project in Texcoco "will bring consequences for the environment such as: poor air quality, deterioration of the area, impact on the habitat of migratory and shorebirds, as well as damage to surrounding towns." (El Financiero, 10/25/2018).

Today, more than 4 years after the cancellation, the site where the NAICM was going to be built is abandoned, and the works that were left unfinished appear flooded by the rains "far from having a policy in favor of nature, the López Obrador government "It has given a great boost to other megaprojects that are devastating to the environment" (Villanueva, 08/25/2020).

Mayan Train, a devastating project for the environment, at the same time, the way in which the decision was made is controversial. The Mayan Train is a work that, "before starting his mandate in 2018, AMLO proposed as one of the main infrastructures works to be built during his government" (Blanco, 07/28/2022). The main controversy with the construction of the Mayan Train, following (Medellín, as cited in Blanco, 2022) is related to the environmental impact; For example, issues related to the destruction of the jungle, the impact of cenotes or the modification of ecosystems due to changes in the project route.

"The Greenpeace organization is now joining the protests, asking the president to avoid an irreparable environmental impact. López Obrador defends that the work will bring benefits, and affirms that they have the support of indigenous communities in the area" (Cano, 04/01/2022).

It is important to highlight that voices of protest have been raised regarding the fact that they have never seen an executive plan that specifically indicates what the implications of the project will be.

The Dos Bocas refinery in the state of Tabasco is a refinery that is being built in an era focused on renewable energy. "Pemex is building the Dos Bocas refinery in an area it promised to protect. Between 2006 and 2007, the oil company promised not to touch a mangrove forest in exchange for the right to drill nearby" (De Haldevang, 07/28/2021).

However, "public documents reveal that Dos Bocas, one of President Andrés Manuel López Obrador's favorite projects for his native Tabasco, is being built in an area that the state oil company had promised to protect" (De Haldevang, 07/28/2021).

A 2008 study conducted by the state-run Mexican Petroleum Institute for PEMEX revealed that "Dos Bocas was the worst of seven potential sites considered for a new refinery due to environmental and social reasons, including the presence of mangroves and the risk of flooding" (From Haldevang, 07/28/2021).

It is noteworthy that the hydrocarbon sector is detrimental worldwide, however, renewable energies are emerging with great potential.

The current Government of the Republic has emerged from the dilemma it found itself in in 2018, when it came to power. At that time, Mexico had a track record in recent years of meeting climate change goals, however, it moved away in search of a higher popularity index among the population.

He turned his economic policy to the Stabilizing Development model, which was based mainly on a division of labor between the government and businessmen.

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In this model, contradictions and polarization are observed with international agreements to contribute to the fight against climate change, among others:

1. Insufficiency of adaptation and mitigation measures to face the effects of changes in land use and nature, caused by the works promoted by the current Government. These works generate greater emissions of greenhouse gases, destruction of protected natural areas, attacks on established cultures and socioeconomic uncertainty, among other negative externalities.
2. Indetermination of anthropogenic impacts to the environment, which were not considered in the production costs due to environmental damage
3. Promotion of the Stabilizing Development economic model, which puts its interest before the growth of production, reductions in inflation rates and stability in exchange rates.

Failing that, climate change policies must be closely related to economic policies for climate change. Therefore, it is necessary to think about a sustainable economy that harmonizes international commitments regarding climate action policies, among others, the 2030 Agenda, the Paris Agreement. Certainly, to think about a harmonious economic model today is to think about a model based on the Degrowth Theory. Without a doubt, this requires the participation of civil society, academia, and the private sector, through an exercise of governance and not imperial politicking.

Political-environmental disagreement

Disagreement between international policies for the use of renewable energies and the actions of the Government of Mexico. As if it were a baseball match between developed and developing countries where the result is anticipated, this is what happens in the field of international policies for the use of renewable energies where the "action" of our country We imagine before they happen.

On the one hand, the UN seeks to transform access and transition to clean energy or renewable energy, remember that "these are replaced faster than they can be consumed, an example of these sources are sunlight and wind." (ONU, s/f), on the other hand, the Government of Mexico expands the Dos Bocas refinery and purchases the Deer Park refinery, the latter "since 1992 was managed in co-ownership by the Dutch company Shell and the state company Petróleos Mexicanos" (Brooks, 12/27/2021). Without a doubt, the Government of Mexico bet on the Development Economy at a time when the world moves towards replacing oil with other renewable energies.

High-level dialogue results in a global roadmap for universal energy access and transition. "On September 24, 2021, more than 130 world leaders, including heads of state and government, ministers, executive heads of UN entities and international organizations, joined the High-Level Energy Dialogue and announced ambitious goals, actions of transformation and bold investments to achieve universal access to energy and net zero emissions" (09/24/2021), in the year 2050, among those present was the Mexican Foreign Minister Marcelo Ebrard. Let us remember that net zero emissions "indicate cutting greenhouse gas emissions until they are as close as possible to zero emissions, with some residual emissions that are reabsorbed from the atmosphere through, for example, the ocean and forests" (UN, s /F). "The commitments made aim to provide hundreds of millions of people with access to clean energy and accelerate the energy transition while creating green jobs to leave no one behind." (09/24/2021).

In this sense, the United Nations (s/f) points out "Current national plans have fallen short." Therefore, a 45% reduction in greenhouse gas emissions is necessary by 2030, compared to 2010 levels, so that global warming does not exceed 1.5ºC" (UN, s/f). It is important to note that the combustion of the 340 thousand barrels per day that the Dos Bocas refinery will produce will emit around 6% more carbon dioxide.

The dialogue of the deaf results in a technically and financially unviable refinery. "On March 18, 2019, the federal government launched a tender restricted to four companies with experience, but also with questions in the field of refining" (Reforma, 10/14/2021).

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Two months later, "the Ministry of Energy (Sener) announced that the tender was declared void, since none of the companies met the requirements of completing construction in three years (...) Pemex and Sener took the reins of the project, with the promise of respecting the budget and having it ready by May 2022, as the President offered" (Reforma, 10/14/2021). Among several inconveniences due to its construction, the Mexican Petroleum Institute (IMP) "warned about the possibilities of flooding at the Dos Bocas refinery, Tabasco, both in an analysis carried out in 2008 and in the Environmental Impact Statement (MIA) of these oil facilities presented in 2019" (Badillo, 10/21/2023). And the premonition came true "The municipal president of Paraíso, Anita Castellanos stated that the Olmeca Refinery located in the Port of Dos Bocas is flooded due to heavy rains. The mayor indicated that 80% of the municipality faces flooding problems since the Seco River overflowed at midday and they are also affected by the construction of the Refinery. Consequently, "Achieving autonomy in oil refining at any cost may be a task based on a nationalist narrative that leaves rational decision aside" (Deloya, 01/26/2022).

In conclusion, the historical disagreement between international policies for the use of renewable energies versus national policies, held in Tabasco, and despite the hypothesis that developed countries defeat developing countries, the dialogue between the deaf He dispatched the game without a hit, or runs to those in high-level dialogue. Well, despite the Paris Agreements, the Degrowth Economy, the Sustainable Economy, the obsession with the highest possible number of Gross Domestic Product emerged victorious. Here and now, we need to harmonize the Mexican economy with international commitments, build a climate action policy from Governance.

Urban-environmental controversies

Current urbanization in Mexico drives Climate Change. Graizbord, (2010) points out "The size, growth rate and distribution of the population in the national territory are the relevant data to understand the demographic pressure on resources and environmental services; but other dimensions must be added."

For example, experts from the UNAM warn "The climate of Mexico City and the Metropolitan Area has increased, mainly due to the change in land use and the disorderly growth of the territory and number of residents, which leads to registration increase in temperature, among other phenomena" (Castro and Luyando, 2021).

The Guadalajara Metropolitan Area is not immune to this situation. In Zapopan, some of the spaces that interact mostly with risks associated with climate change paradoxically coincide with the zoning of strategic spaces that has delimited the so-called "Municipal Strategy for Urban Prosperity 2030", these are El Colli and Las Mesas. In the latter, in 2018, 39 damaged homes were reported, of which three collapsed (Gran, 2019).

In conclusion, we point out that Mexico has signed several agreements on Climate Change. It is noteworthy that these contain instruments to formulate, implement and evaluate the results of these agreements within the country. However, it seems that these instruments and actions in the national territory have been somewhat forgotten. In this case, it is urgent to develop policies, projects, regulatory and evaluation instruments on climate change under state and municipal jurisdiction, which are disaggregated from the commitments acquired at the international level. Although we are behind, the Mexican population and its territory cannot wait any longer. Urbanization in the Guadalajara Metropolitan Area The urbanization model of the Guadalajara Metropolitan Area (AMG) is based on chaos, which in turn contributes to climate change.

The Secretariat of Agrarian, Territorial and Urban Development (SEDATU) points out that "during the second half of the 20th century, urban areas grew in a disorderly and uncontrolled manner" (Herrera, 2014). For her part, Patricia Martínez, Director of the Metropolitan Planning Institute (IMEPLAN), pointed out that, "as a consequence of urban growth, between 2018 and 2022, 1,568 hectares of natural areas were lost, with environmental protection zones representing 77 percent of the loss (Milenio, 01/26/2023). The urbanization of the AMG in the last 70 years generated population concentration and territorial distribution of different intensity.

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The conurbated municipalities of the AMG have had heterogeneous urban growth. During the first three periods of 1940-1950, 1950-1960 and 1960-1970 Zapopan, Guadalajara and San Pedro Tlaquepaque had the highest growth rates in the Guadalajara Metropolitan Zone (ZMG). With average rates around 4.5 for the first; 6.50 for the second; and 7.60 for the third. During the periods of 1970-1980 and 1980-1990 Zapopan, Tlquepaque and Tonalá reached an average rate of 7.60. In the period 2000-2010 Tlajomulco de Zúñiga reached a rate of 12.48 and Ixtlahuacán de los Membrillos 9.42 (Institute of Territorial Information of the state of Jalisco, 2013). In short, until the end of the last century, urbanization extended horizontally to the municipalities surrounding the city of Guadalajara; On the other hand, so far this year, urbanization has grown uncontrollably towards the remaining municipalities of the AMG, through a chaotic expansion.

The expansive and dispersed urban structure of the AMG favors greater carbon dioxide emissions through the combustion of fossil fuels. The urban growth of the AMG formed an urban structure that was both expansive and dispersed, mainly towards the corridors of López Mateos and Adolf Horn avenues in the municipality of Tlajomulco de Zuñiga, and towards the town of Tesistán, in Zapopan (Barajas, 2023). This growth "in terms of number of inhabitants, surface area and physical extension, produces congestion and increases the distance to travel when traveling to work" (López and Gómez, 2022).

According to (Levine et al., 2019, cited by López and Gómez 2022), urban accessibility is the result of the interaction between three elements: mobility, proximity and connectivity. Regarding the urban accessibility of these corridors, it is observed that public transportation, which should reach the destinations considering investment and time, does not achieve the goal; proximity, which refers to the distribution in the territory of origins and destinations, is not relevant; Connectivity, whose consideration is access to goods or services in people's place of residence, is not achieved. In short, the search to achieve mobility, proximity and connectivity has increased the use of public and private vehicles, in turn, the impact on the environment due to gas emissions caused by the burning of fossil fuels.

Given this reality, the need arises to identify the scope that the legal and normative has had in the chaotic conformation of the current urban structure.

On the one hand, the municipalities neighboring Guadalajara were characterized until 1992 by having a significant percentage of ejidal land in their jurisdiction. In this sense, the 1992 Agrarian Reform Law was approved, with the main purpose of regularizing the land market in agrarian centers, giving certainty to land tenure; On the other hand, in 1993 the Urban Development Law of the State of Jalisco was approved, whose objective was to dictate the necessary measures to organize human settlements in the state of Jalisco.

In conclusion, three decades after the approval of the Agrarian Reform Law and the Urban Development Law of the State of Jalisco, and the programs that derive from it, the Municipal Urban Development Program and the Partial Urban Development Plans of the municipalities that make up the AMG, today there are corridors of subdivisions around the main highway exits of the Metropolitan Area of Guadalajara, Colima, Nogales, México, Chapala and Zacatecas and an important urban dispersion, where some areas reach an extreme construction density and , others, an opposite behavior.

In addition, a notable increase in vehicles has been observed, reaching 220% in the last two decades, a situation that triggers the consumption of gasoline and diesel. Given this reality, it is urgent to review and/or apply the Environmental Law of Mexico, the State Law of Ecological Balance and Environmental Protection of Jalisco, the Urban Code for the state of Jalisco, in addition, the Real Estate Law of Jalisco, among other legislations.

Results

Colonies in the southeast of the municipality of Zapopan, Jalisco, present insufficient mitigation and adaptation measures to face floods. "The measures aimed at reducing the vulnerability of natural and human systems to the real or expected effects of climate change are known as adaptation" (National Institute of Ecology and Climate Change, 05/18/2018).

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In this context, the guiding instruments of the national policy on climate change are the General Climate Change Law (LGCC), the National Climate Change Strategy and the Special Climate Change Program. The LGCC establishes the objective of "reducing the vulnerability of society and ecosystems to the effects of climate change, and strengthening the resilience and resistance of natural and human systems" (National Institute of Ecology and Climate Change, 05/18/2018). Despite legislation, strategies and programs to address the vulnerability of society and ecosystems, the southeast of Zapopan remains forgotten and its territory growing uncontrollably.

Floods in the southeastern neighborhood of Zapopan, resulting from the overflowing of two streams, are frequent incidents. The severe floods that hit the southeast of Zapopan in 2021 and 2022 were caused by the overflowing of the "Arroyo Seco" and the "Garabato". In this area surrounding the Bosque de la Primavera and El Bajío, more than a dozen neighborhoods were affected, including "Miramar, Tizate, Mariano Otero, Villas de la Primavera, Jardines Tapatíos, 12 de Diciembre, Carlos Rivera, Colinas de la Primavera, Lomas de la Primavera and Arenales Tapatíos" (López, 02/28/2023). It is important to recognize that the affected neighbors point out "...every year their streets flood (...) it had been at least five years since the "Arroyo Seco" had overflowed, but this time the storm took them by surprise" (Niño, 07/25/2021), for this reason, these events are not isolated, they are incidents that occur every rainy season.

Deforestation and construction of subdivisions caused the overflowing of the two streams. The collapse of the "El Seco" and "Garabato" streams according to Alejandro Banda (Ortega, 10/17/2022), a resident of the area, mentions that the floods "were caused because part of what is The Bajío area where all the water flowed, there was a detour through the subdivisions that they built, a detour towards the bed of the Garabato and Arroyo Seco rivers, which filled the gabions" (sic). About the floods, Mr. Luis Valdivia Ornelas, researcher at the University Center of Social Sciences and Humanities (CUCSH), pointed out, "another variable is that urban growth transforms the channels, they can disappear, become segmented or lose their conduction capacity due to invasions or changes in the geometry" (Serrano, 05/19/2022).

Therefore, based on these statements and specialized literature we can establish that the transformation of natural and permeable surfaces to concrete slabs has caused floodable surfaces to increase and flooding to be more severe.

From forest to concrete, a transformation resulting from human activity that contributes to climate change. According to the World Bank's statement regarding forests, these "are the main carbon stores on our planet. However, when trees are cut down for agricultural reasons or to build infrastructure, large amounts of carbon dioxide and other greenhouse gases are emitted into the atmosphere, contributing to climate change." At the same time, standing forests help decisively address the impacts of climate change not only by absorbing greenhouse gases, but also by creating landscapes with greater resilience" (World Bank, 03/18/2018). In summary, forests regulate the flow of water, improve and maintain the soil to protect the population; on the contrary, concrete slabs violate sustainability and put society at risk.

International, national, state and municipal agreements and the deaf ears of the authorities. After the Paris Agreement, several countries have shown a strong commitment to their climate action plans on adaptation measures. The Government of Mexico, through the General Congress of the United Mexican States, issued the new General Law on Climate Change, which states that the principles, among others, of:

I. Sustainability in the exploitation or use of ecosystems and the natural 696 elements that make them up.
II. Caution, where there is a threat of serious or irreversible damage, the lack of full scientific certainty should not be used as a reason to postpone mitigation and adaptation measures to address the adverse effects of climate change.

Adaptation actions will be considered, as indicated in Article 29, among others:

I. The determination of the natural vocation of the soil.
II. The establishment of population centers or human settlements, as well as their development, improvement and conservation actions.

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III. The construction and maintenance of infrastructure.
IV. The protection of flood zones and arid zones

To this end, the agencies and entities of the centralized federal and parastatal public administration, the federal entities and the municipalities, within the scope of their powers, will implement actions for adaptation. However, the reality is different, Guadalupe, a neighbor of the Miramar neighborhood, points out "Unfortunately they did not listen to us about the retaining wall. We fight a lot for a retaining wall here in Puerto Tehuantepec, because the bridge is very small and does not supply all the water that comes down from above. Here are the consequences" (Ortega, 10/17/2022).

This type of accusation confirms that the neighbors displace the co-responsible authorities and they are the ones who suggest adaptation measures. The neighbors' perception is of abandonment by the authorities.

The authorities of the three levels of government fail to comply with their obligations, therefore, they should be held accountable. "The Paris Agreement is a legally binding international climate change treaty. It was adopted by 196 Parties at COP21 in Paris, on December 12, 2015 and entered into force on November 4, 2016" (United Nations, s/f).

However, what happened in the southeast of Zapopan is an event that is reproduced at the municipal, state and national level. Faced with this reality, society as a whole must begin a local and global crusade to publicize the dismantling of the mitigation and adaptation measures that exist in our country, due to the complacency or omission of the authorities, and the state of vulnerability in that places the population and ecosystems, and legally bind whoever is responsible. If we are not able to sustain our dignity, we will not be able to sustain our country.

El Arroyo Seco and Arroyo El Garabato are located south of the municipality of Zapopan, Jalisco. According to the Mural newspaper (06/12/2023) "Between 2019 and 2021 alone, the Arroyo Seco has overflowed and caused flooding on 17 occasions in Zapopan."

It should be noted that due to the flooding suffered by the colonies El Tizate, Colinas de la Primavera, Arenales Tapatios, Miramar, Lomas de la Primavera, La Floresta del Colli, Carlos Rivera Aceves, El Briseño, El Fortín, Mariano Otero, Brisas de la Primavera , Cantaluna, Campestre Los Pinos, El Mante, Miramar Poniente, Paraísos del Colli, El Rehilete, Residencia San Nicolás, Valle de San Nicolás, Villas de la Primavera and those located in the vicinity of Arroyo El Grande and Teisquinque, in the municipality of Zapopan, Jalisco, the Zapopan City Council, issued a Declaration of Emergency for the municipality of Zapopan.

Regarding the problem that has caused these floods, the State Commission on Human Rights, in a special report that it prepared on the La Primavera Forest, points out that this stream "has its origin in said ecosystem that is impacted by fires, filling of channels, garbage and invasions of human settlements,..." (CEDHJ, 2023). For his part, Luis Valdivia Ornelas, CUCSH researcher, indicates that "...the variables that are involved in the genesis of these because not only rain is involved, but the transformations in natural conditions due to urban growth; that is the determining factor..." (Aréchiga, 05/17/2023). The Master Luis Valdivia Ornelas, researcher at the University Center of Social Sciences and Humanities (CUCSH), pointed out, "another variable is that urban growth transforms the channels, they can disappear, become segmented or lose their conduction capacity due to invasions or changes in the geometry" (Serrano, 05/19/2022).

In the case of the affected neighbors, they point out that "although their streets flood every year, the water never exceeds the level of the sidewalks and it has been at least five years since the Arroyo Seco overflowed, but this time the storm It took them by surprise. They say that in the area it did not rain that hard and, however, the current came with great force" (Niño, 07/25/2022). According to Alejandro Banda (Ortega, 10/17/2022), a resident of the area, he mentions that the floods "were caused because the part of the Bajío area where all the water flowed was diverted, there was a diversion Because of the subdivisions they built, a detour towards the bed of the Garabato and Arroyo Seco rivers, which filled the gabions" (sic).

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Axis 2. Territory

As mentioned previously, the floods that this work refers to are located in the lower part of the La Primavera Forest, however, as the researcher from the Department of Geography and Territorial Planning of the CUCSH Luis Valdivia Ornelas points out, the consequences of the floods of previous years They are a product of the poor urbanization that takes place in the upper parts of the city.

For example, industrial areas, shopping centers, parking lots are being built in the higher parts, so the increase in damage is exponential and that is causing a greater increase in damages and for example it is being observed in Garabato where before it did not overflow, in addition, the The developments that are taking place in the upper part of Mariano Otero are increasing the overflow problem in the lower areas of Arroyo del Garabato and in Santa Anita, not to mention El Palomar or El Cielo where commercial infrastructure is being built in the upper part. In this sense, although the problem is observed in the colonies mentioned above, the effects are broader, therefore, it must be considered that the territorial impact goes far beyond the colonies mentioned.

Axis 3. Intervention or attention

In consideration of the problem, the problem and its territorial impact, the proposal is oriented towards Prevention, with the application of the corresponding laws; Adaptation, through measures that consider the change of residence of inhabitants who are in vulnerable areas due to river waters and the havoc they cause, in the population and in the territory; and, Mitigation, through infrastructure works that channel river water volumes.

Conclusions

The south of Zapopan is flooded by the urban growth that the lower area of Bosque La Primavera and the El Bajio area, Zapopan, have had. To a question asked to Mr. Luis Valdivia Ornelas about Why is Guadalajara flooding? He responded “Another variable is that urban growth transforms the causes, they can disappear, become segmented or lose their conduction capacity due to invasions or changes in geometry.”

The Master Luis Valdivia continues with his statements, "An example of this situation is what happens in the area of Juan Palomar and Arias avenues, in Zapopan, where said road completely cut off the runoff coming from Bajío and San Juan de Ocotán, which gives origin to the Atemajac River” (Serrano, 2022). In short, an environmental problem is a negative alteration in the environment that affects natural elements.

El Bajío area, just a look at the toponymy was enough to have made sustainable urban decisions. El Bajio is an area of Zapopan that is located at the coordinates: latitude 20º41'38N and longitude 103º26'58W. On September 3, 2019, the “Decree of the Governor of the State of Jalisco was approved, establishing “El Bajío” as an environmental recovery zone, with an area of 980.89 hectares, located in the municipality of Zapopan, Jalisco, as well as the El Bajío Environmental Recovery Program and its annexes” (Government of the State of Jalisco, 2019). The Secretariat of Environment and Territorial Development (SEMADET), stated “The El Bajío area represents one of the most relevant areas for the recharge of aquifers within the Guadalajara Metropolitan Area (AMG). The water that infiltrates emerges in lower parts of the basin and is used for human use. The Atemajac River is born from the water infiltrated in this area. The area is composed of Quercusy Pinus mixed forest, induced shrubland and induced grassland. In short, it seems that the environmental policies in the state of Jalisco and the municipality of Zapopan are corresponding with Mexican environmental policies and with the international agreements to counteract climate change that Mexico has signed, however? Real estate speculation in El Bajío is above the interest of citizens and sustainability. “A citizen obtained a ruling from a federal judge against the decree of the governor of Jalisco establishing El Bajío, in Zapopan, as an environmental recovery zone.” This, therefore, was interpreted that "the decree of the governor of Jalisco affects the right to property and possession of the complainant, since it limits him from the free disposal of the property he owns for the use he wants to give it" (Observatory of Socio-Environmental Conflicts , 02/12/2022).

Let us remember that the protected polygon covers hectares, of which 315 are already urbanized, part of it with the Akron stadium, the Pan American Villages, etc.

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In conclusion, we mention that the El Bajío area in Zapopan is a strategic place for collecting river water, which supplies the metropolitan area and properties of Colomos and the Atemajac Valley.

However, this natural benefit that nature gave us is at risk of being lost due to the urbanization process that currently exists and the construction of the Akron stadium, the Pan American Villages, Judicial City and others. Consequently, the greater the urbanization, the greater the flooding, as we remember that housing, commercial and industrial developments in the area have modified the natural vegetation cover of the soil with concrete slabs, consequently, a change in runoff. What awaits us? If we wait there will be droughts, floods, greater environmental pollution; If we stand up, socio-environmental justice, resilience, regularization and a better quality of life and a contribution to the planet.

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Salas-Tafoya, José Manuel: Research coordinator, Research approach, Research approach, Development of the research

Valenzuela-González, Elizabeth: General contribution to the research development

Porras-Zárate, Iván: Documentary and statistical analysis of information

Hernández-Valenzuela, José de Jesús Nicolás: Documentary analysis of the information

The adaptation actions correspond to resiliency the territory affected by the overflows of the two streams, for this the following is required:

1. Reorganize the cause of the two streams and give it the appropriate surface (volumetry) to conduct the waters. A hydrological study must be carried out, which considers the most catastrophic scenarios, based on the history of the two streams and the floods.
2. The inhabitants who live in the vicinity of the two streams must change their residence, based on scientific studies and relevant legislation.
3. Civil engineering elements must be built to ensure that the cause of the two streams does not invade the estimated surface area.
4. Environmental impact and cost-effectiveness studies must be carried out to reconcile federal, state and municipal expenditures and benefits and effectiveness.
5. The benefits will be a better quality of life for the inhabitants of the area, this contributes to the eradication of poverty. In addition, psychological, health, work stability, sense of belonging and social cohesion, highlighting governance.

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Article

Pressure drop prediction by a polynomial model for two-phase flow in vertical oil wells

Predicción de la caída de presión por un modelo polinomial para flujo bifásico en pozos petroleros verticales

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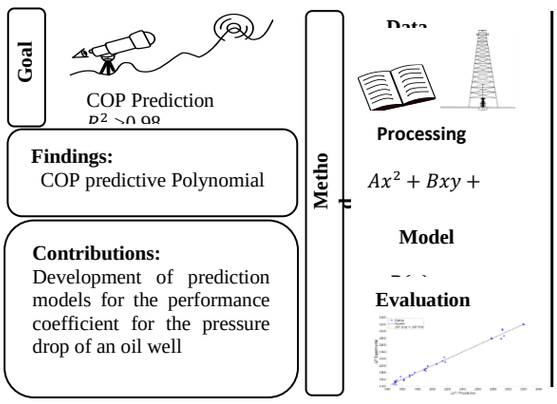
Resumen

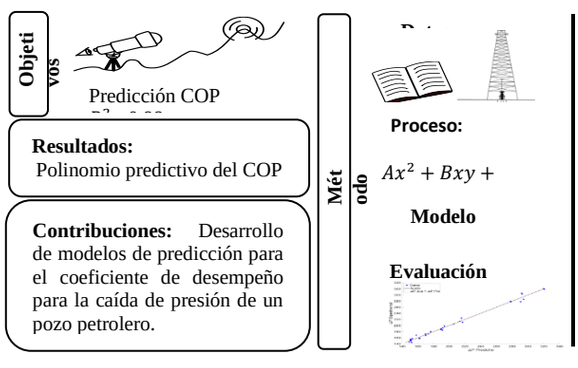
In this paper, a polynomial model is developed to predict the pressure drop in oil wells with two-phase flow. The variables used in the model are gas-oil ratio production, oil production, tubing diameter, solution gas-oil ratio, oil formation volume factor, and oil viscosity. A polynomial model is presented to predict the pressure drop with a coefficient of determination of 0.9901. The residual analysis and level surfaces of the pressure drop against the polynomial model's input variables are presented to validate the model. A regression of the experimental and predicted pressure drops values using the polynomial model is presented. This model contributes to a simpler methodology for the calculation of pressure drops and the consequent application in the modeling of production curves in oil wells for NODAL analysis.



Two-phase flow, residual analysis, validate, regression, experimental, and polynomial model

Resumen

Se desarrolla un modelo polinomial para predecir la caída de presión en pozos petroleros con flujo bifásico. Las variables utilizadas en el modelo son producción de la relación gas-aceite, producción de aceite, diámetro de la tubería de producción, relación de solubilidad, factor volumétrico de formación del aceite y viscosidad del aceite. Un modelo polinomial es presentado con el objetivo de predecir la caída de presión que tiene un coeficiente de determinación de 0.9901. Con el objetivo de validar el modelo son presentados el análisis residual y superficies de nivel de las caídas de presión contra las variables de entrada del modelo polinomial. Se presenta una regresión de los valores de caída de presión experimental y predichos mediante el modelo polinomial. Este modelo contribuye en una metodología más simple para el cálculo de las caídas de presión y la consecuente aplicación en el modelado de las curvas de producción en pozos petroleros para su análisis NODAL.



Flujo bifásico, análisis residual, validación, regresión, experimental y modelo polinomial

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Introduction

During production in hydrocarbon wells, two-phase flow is encountered, which complicates the calculation of various phenomena that occur during the trajectory of the fluid inside the pipe. That is to say, during the period in which the fluid travels through the pipe, it is very common for there to be a change in the distribution of the fluid, and it is also possible to find hanging of the liquid. One of the main variables that is affected for its study is the pressure drop that occurs in this flow path. In order to calculate the pressure drop, it is necessary to use mechanistic models that explain the behaviour of multiphase flow in the pipe according to all the variables included in the processes of this phenomenon. These mechanistic models, which have been developed for decades, have their application problems, due to the limited conditions in which they were developed and therefore they are not accurate in general conditions or far from the original conditions in which they were created.

There are numerous models that have been proposed in the literature to calculate the hydrocarbon pressure drop, some of the most important models are those presented in (Beggs & Brill, 1973) which considers the fluid hang-up as well as the flow regime. The model of the authors (Hagedorn & Brown, 1965) considers the calculation of gravity and friction pressure drops, using the fluid hang-up to determine the gravity pressure drops, but without considering the flow regime. The aforementioned models can be complex in terms of calculations, which is why, in this work, a polynomial function is proposed to predict the pressure gradient calculation.

A polynomial function is obtained by means of a multiple linear regression analysis, the objective is to predict the pressure drop knowing the experimental measurements of some variables associated to this process. In fact, polynomial fitting is an attractive technique used to estimate the dependent variable in a system knowing experimental data of the independent variables associated with the system under study, see for example (Escobedo-Trujillo et al., 2014) for more details of the technique. There are different prediction methods such as the machine learning techniques studied in (Dabiri et al., 2024), it is up to the researcher to choose the one that best fits their experimental data.

For this article we used the experimental data of the authors (Chierici et al., 1974) which are given in the first section, then in section 2 we mention the methodology used for the development of the polynomial model and in section 3 we show the results of the polynomial model obtained and its respective residual analysis to verify the goodness of fit or prediction, and finally in section 4 we conclude with the contribution obtained from this work.

Experimental data

The database used in this work was obtained from the research work (Chierici et al., 1974). This database was chosen because it had fluid properties such as solubility ratio and volumetric factor of the oil, unlike the work (Espanol et al., 1969) which only provides flow data and mechanical characteristics of the wells. The Chierici database shows information on 10 variables that affect pressure drops such as: oil specific gravity, gas-oil ratio, water cut, oil volumetric flow, well diameter, temperature, solubility ratio, oil volumetric factor, oil viscosity and gas specific gravity; this information is from 31 oil wells. Table 1 shows the variables with their respective operating ranges.

Box 1

Table 1

Ranges of operations under experimental conditions to obtain pressure drop values

Variable	Rango de operación
Specific gravity of oil (γ_o)	8.3-46
Production of gas-oil ratio (GOR)	25.9 - 404.6
Water cut (W_c)	0-0.5
Oil production (Q_o)	7 – 1848
Diameter of production line (D)	2.8750 - 5
Temperature (T)	27.2-77.2
Solubility ratio (R_s)	22.9 - 404.6
Volumetric oil formation factor (B_o)	1.1398 - 2.4360
Oil viscosity (μ_o)	0.160 - 77.20
Specific gravity of the gas (γ_g)	0.571-1.705
Pressure drop (ΔP)	144.4-320.2

Methodology

The relationship of the pressure drop to the variables that directly affect it, the fluid properties and well characteristics can be approximated by a polynomial model of the form: $\Delta P_{experimental} \approx p\left(d, l, GOR, Q_{oil}, P_{top}, \gamma_o, \gamma_g, \sigma, \rho_o, \rho_g, \mu_o, R_s, B_o, B_w\right)$ where p is an unknown polynomial function.

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In general, the relationship between the variables GOR, Q_{oil}, D, R_s, B_o, μ_o and the pressure drop ΔP can be approximated by a polynomial function of the form:

$$\Delta P_{experimental} \approx p(\text{GOR}, \text{Qoil}, \text{D}, \text{Rs}, \text{Bo}, \mu_o) + \varepsilon, \quad (1)$$

Where ε is a random error. The reduction of the number of variables in the derivation of the polynomial model to be searched for is due to the fact that after performing an analysis of correlations between the independent variables $d, l, GOR, Q_{oil}, P_{top}, \gamma_o, \gamma_g, \sigma, \rho_o, \rho_g, \mu_o, R_s, B_o$ and the ΔP, it was found that the variables that affect the pressure drop the most areGOR, Qoil, D, Rs, Bo, μ_o.

PaIn order to determine the polynomial model described in (1), polynomials were made by combining the variables as shown in formula (2). This equation describes the combinations that are possible to make to obtain the polynomial.

$$\Delta P = \sum_{i=1}^{n} a_i x_i + \sum_{i,j=1}^{n} b_{i,j} x_i x_j + \sum_{i,j,k=1}^{n} c_{i,j,k} x_i x_j x_k + \ldots, \quad (2)$$
$$n = 6$$

The criterion used in this work to select the best polynomial is the coefficient of determination. (R^2) between the proposed polynomial p and the experimental pressure drop $\Delta P_{experimental}$.

Results

In order to implement the methodology given in section 2, the database of the authors' research work (Chierici et al., 1974) was used with the difference that the number of variables mentioned in Table 1 is reduced to just Q_{oil}, GOR, d, R_s, B_o, μ_o y ΔP, This is because the combinations performed showed better results with these variables. Various combinations were made with the previously mentioned variables to find a simple polynomial in algebraic structure. After several algebraic calculations in which a polynomial model was propose d and the coefficient of determination between the pressure drop predicted by the polynomial model and the experimental pressure drop was calculated, the polynomial model selected because of its high coefficient of determination is

$$\begin{aligned}\Delta P \approx\ & 538.8272 + 0.2411(\text{GOR}) \\ & + 0.0788(GOR)(\mu_o) \\ & + 0.0434(Q_{oil}) \\ & - 6.5879x10^{-6}(Q_{oil}^2) \\ & + 1.8547x10^{-9}(Q_{oil}^3) \\ & - 0.0109(Q_{oil})(d) \\ & - 2.9451(R_s) + 0.0177(R_s^2) \\ & - 3.2894x10^{-5}(R_s^3) \\ & - 321.1895(B_o^2) \\ & + 131.8653(B_o^3) \\ & - 1.1807(\mu_o)\end{aligned} \quad (3)$$

The fit of the polynomial model (3) was expressed by the coefficient of determination R^2 which was 0.9901, indicating that 99.01 % of the variability of the pressure drop could be explained by this polynomial model. Figure 1 shows the linear relationship of the experimental pressure drop ($\Delta P_{experimental}$) y the one predicted by the polynomial model (p) with a coefficient of determination value of 0.995.

Box 2

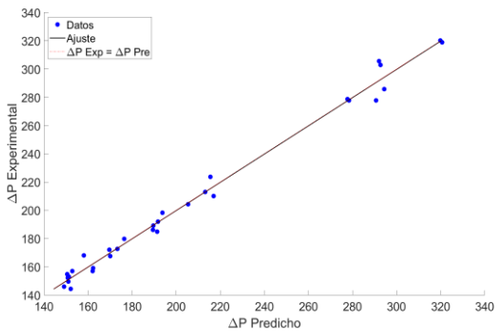

Figure 1

Regression of experimental and predicted pressure drop values using the polynomial model.

Source: Own elaboration.

Graphically in Figure 1 we can see that $\Delta P_{experimental} \approx p(\text{GOR}, \text{Qoil}, \text{D}, \text{Rs}, \text{Bo}, \mu_o) + \varepsilon$,

On the other hand, let us recall that the variables involved in the polynomial model are: GOR, Q_o, D, R_s, B_o y μ_o, then to give a geometric idea of the behaviour of the polynomial p, the experimental (ΔP_Experimental) and predicted (ΔP_Pre) pressure drops are plotted, however, it should be noted that the polynomial has six different variables, Therefore, level surfaces are plotted for each variable, in the two-dimensional ones, one of the variables of the polynomial is varied and the others are left fixed (see Figure 2) and in the three-dimensional ones, two variables are varied and the others are left fixed (see Figure 3).

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As can be seen, there is good agreement between the values predicted by the polynomial model and the experimental data of pressure drops in oil wells.

Box 3

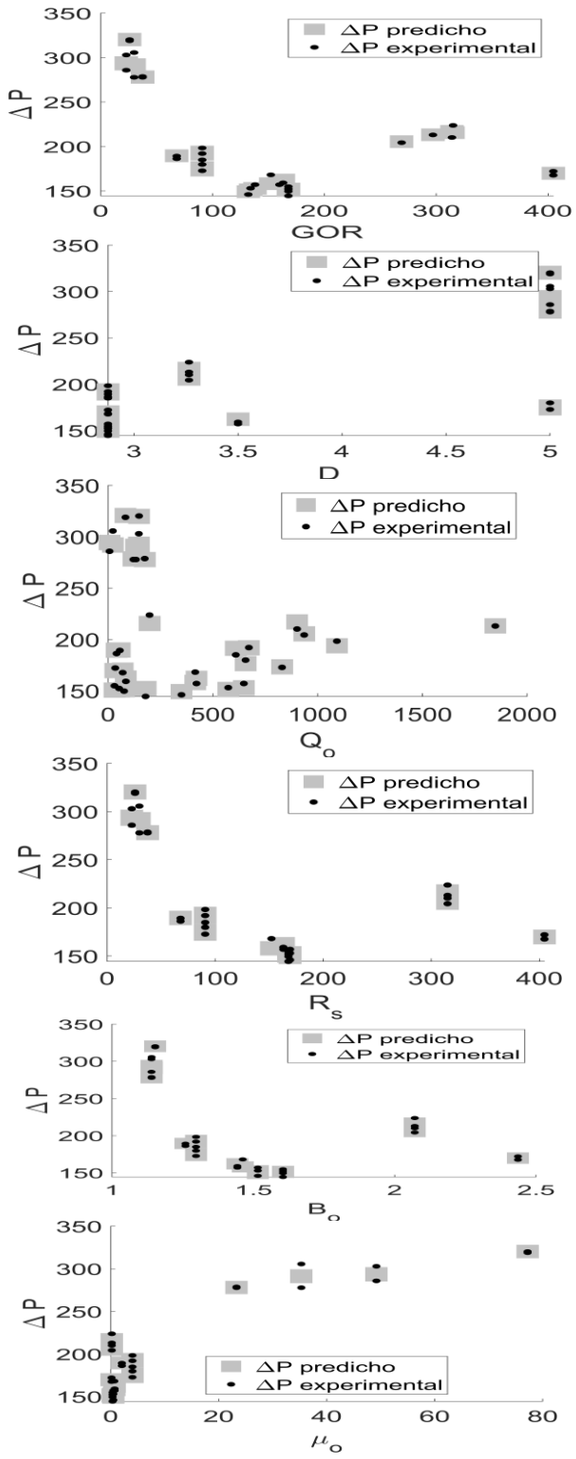

Figure 2

Contour lines. Comparison of experimental pressure drops $(\Delta P_{experimental})$ **and the predicted by calculating the** $\Delta P_{predicha} = p(\mathbf{GOR}, \mathbf{Qoil}, \mathbf{D}, \mathbf{Rs}, \mathbf{Bo}, \mu_o)$ en function of one variable at a time and leaving the rest of the variables as constants..

Source: Own elaboration.

Box 4

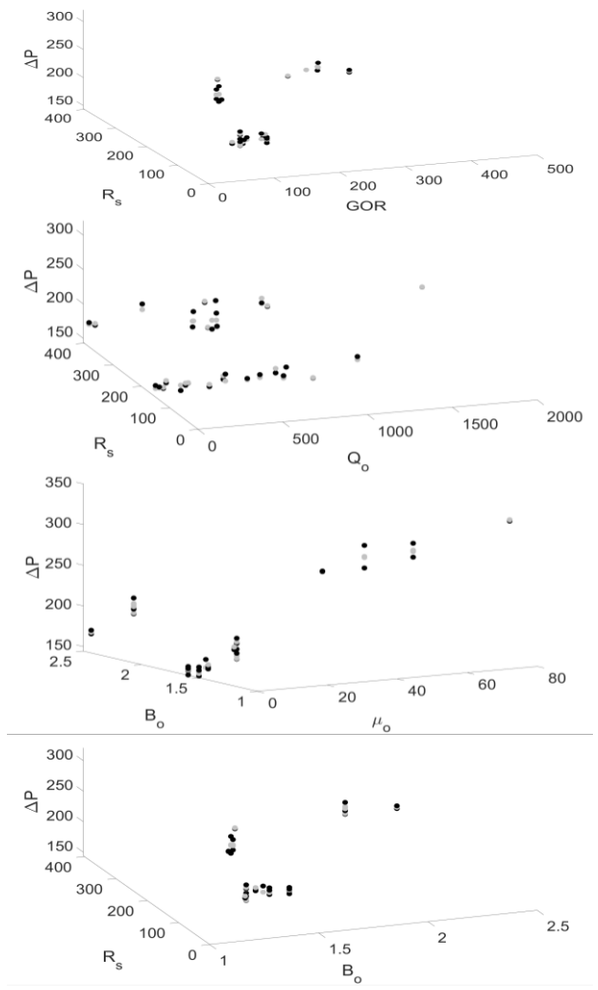

Figure 3

Level surfaces. Comparison of experimental and predicted pressure drops by calculating the ΔP as a function of two variables at a time and leaving all other variables as constants.

Source: Own elaboration

Residual analysis

Recall the existence of a random error ε in (1). To mathematically demonstrate the good polynomial fit of the given model (3), a residual analysis is performed to analyse the behaviour of this random error (Montgomery & Runger, 2003). To this end, note that taking the average value (E) in (1) we get $E(\Delta P_{Experimental}) = E(p(\text{GOR, Qo, D, Rs, Bo, } \mu_o) + \varepsilon)$

Which by the properties of the average value is the same as

$$\Delta P_{Experimental} = p(\text{GOR, Qo, D, Rs, Bo, } \mu_o) + E(\varepsilon) \quad (4)$$

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Note that, from (4), the experimental pressure drop and the polynomial $p(\mathrm{GOR, Qo, D, Rs, Bo, \mu_o})$ se Therefore, we proceed to verify graphically that E(ε)=0. In order to carry out such a verification, note that from (1) we obtain that the residuals or random errors ε are expressed by the following difference

$$\varepsilon \approx \Delta P_{Experimental} - p(\mathrm{GOR, Qo, D, Rs, Bo, \mu_o}). \quad (5)$$

In Figure 4 the residuals or random errors (ε) have been plotted and as can be seen there are values whose confidence intervals do not cross zero, these values are called outliers, in the graph there are 2 outliers marked in red, i.e. 93.54% of the residuals pass through 0. Finally, it is crucial to know if these outliers affect the proposed polynomial model (3), for this reason the 2 outliers were removed and the regression was redone without these points and a coefficient of determination of R2 = 0.9933 was obtained. The difference is 0.0032, this result infers that the outliers do not represent a significant amount for the polynomial model proposed in (3). On the other hand, the histograms of the standardised random residuals were performed, see Figure 5, you may notice from that figure the mean of the random errors is approximately zero, i.e. E(ε)≈0. The latter allows us to conclude that indeed on average the experimental pressure drop and the pressure drop predicted by the polynomial model (3) coincide because the average of the random errors is zero.

Box 5

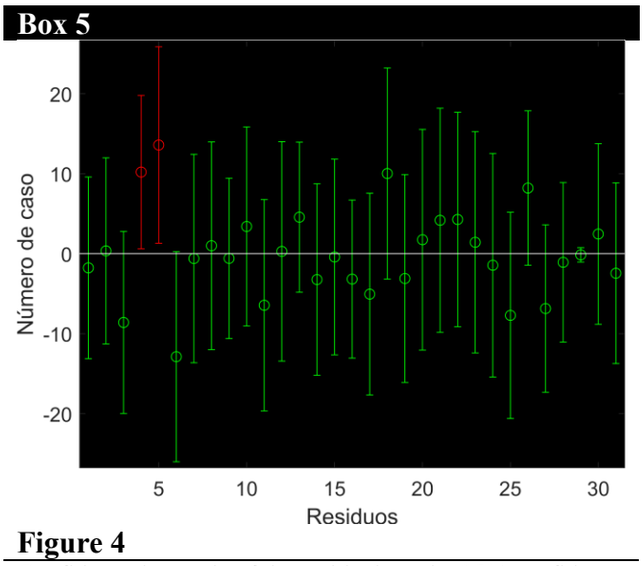

Figure 4

Confidence intervals of the residuals at the 95% confidence level

Source: Own elaboration

Box 6

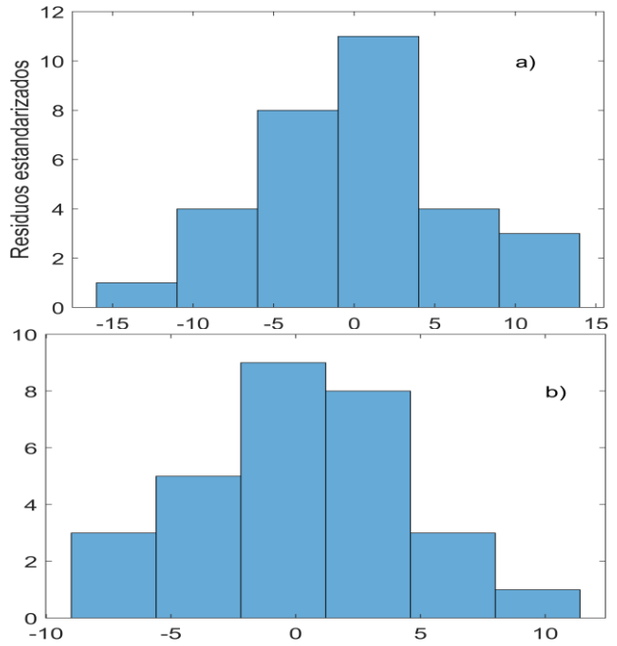

Figure 5

Confidence intervals of the residuals at the 95% confidence level.

Source: Own elaboration

Conclusions

The conclusions obtained through the development of this polynomial model were the following. Through the multiple linear regression analysis, a polynomial function of the variables related to the process of pressure drops in two-phase oil wells was successfully obtained.

The results obtained with the fit showed a high accuracy with the experimental data R2 > 0.99. In addition, a standardised residual analysis was recommended in addition to the coefficient of determination to check that the average random error value was zero to ensure a good fit of the polynomial model (3). As can be seen in the polynomial model, the variables with the greatest effect on the pressure drop are the gas-oil production ratio (GOR), solubility ratio (Rs) and volumetric oil formation factor (Bo) because they are the variables that directly influence the pressure drops by elevation. In two-phase wells, the phase distribution governs the behaviour of the pressure drop, which is why the production gas-oil ratio has a considerable impact on the polynomial model, as do the aforementioned fluid properties such as the solubility ratio (Rs) and volumetric oil formation factor (Bo), which provide information about the ratio of the oil production volume to its volume in the reservoir.

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With the above mentioned, it is concluded that more efforts are required to obtain reliable data on the gas-oil production ratio (GOR), solubility ratio (Rs) and volumetric oil formation factor (Bo) because they are the variables that most affect the pressure drop. This methodology can be used to simplify the complex calculations used to calculate pressure drops.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' contribution

The contribution of each researcher in each of the points developed in this research was defined based on:

Hernández-Santos, Abisai: He contributed to the idea of the project, carried out the data analysis and supported the writing of the article.

Escobedo-Trujillo, Beatris Adriana: Contributed to the idea of the project, method and research technique.

Alaffita-Hernández, Francisco Alejandro: Contributed to the idea of the project, developed the algorithm for obtaining all the figures shown in the work and carried out data analysis.

Colorado-Garrido, Dario: Contributed to the idea of the project, systematised the background for the state of the art, and reviewed the writing of the article.

Availability of data and materials

The database used in this work was obtained from Chierici (Chierici et al., 1974).

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Abbreviations

Not applicable

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Article

Statistical representation of university management as a means for sustainable development in connection with the productive sector

Representación estadística de la gestión universitaria como medio para el desarrollo sustentable en vinculación con el sector productivo

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Abstract

Statistical representation of university management as a means for sustainable development in connection with the productive sector.

Objectives

The objective of this study is the use of statistical tools that estimate the effects of the link made by the HEIs with the productive sector, on the impact on sustainable development.

Methodology

methodological process

Contributions

With the analysis of results it allowed the argument of scenarios

Knowledge of AST industrial advisors and competency model.

Lack of knowledge of the AST industrial advisors and the competency model

Sustainability, MSMEs, Linkage, AST, Logit model

Resumen

Representación estadística de la gestion universitaria como medio para el Desarrollo sustentable en vinculación con el sector productivo.

Objetivos

El presente studio tiene como objetivo la utilización de herramientas estadísticas que estimen los efectos de la vinculación realizada por las IES con el sector productive, en el impacto para el Desarrollo sustentable.

Metodología

Proceso metodológico

Contribuciones

Con el análisis de resultados permitió el argumento de escenarios

Conocimiento de los asesores industriales del AST y modelo por competencias.

Desconocmiento de los asesores industriales del AST y modelo por competencias

Sustentabilidad, MIPyME´s, Vinculación, AST, Modelo Logit

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Introduction

Organisations are constituted with a specific purpose or aim, however, in their productive action, collaborative work has been perceived in isolation, so that the lack of knowledge in the forms of interaction with Higher Education Institutions (HEIs) with MSMEs, limit, based on their advantages and particular characteristics, the generation of a proposal that provides them with the basis for proper management in their processes and linkage with HEIs, Therefore, the academy should consider strengthening through a model that allows HEIs to generate interaction and participation in AST for the strengthening of academic activities as well as help in the management of MSMEs' processes.

Similarly, it is based on the General Law of Higher Education (2021), which establishes the coordination, promotion, linkage, social participation, evaluation and continuous improvement of higher education in the country, being part of the analysis the intervention of the Government for the linkage of HEIs with the productive sector.

The research is in the process of generating strategies for the design of the proposal of the Linkage Model, having as background the tests carried out with the industrial advisors during the periods 2016 and 2017, in such a way that with both theoretical and statistical elements, support the hypothesis and with it the generation of the model, for this the proposal of the triple helix model is taken up, in which the actions to be carried out by each of the subjects involved in the linkage are evaluated, according to Figure 1.

Considering the Triple Helix model supported by Etzkowitz, H., & Leydesdorff, L. (1997), cited by Antonio & Treviño (2018) in the trilateral analysis and its linkage to meet social, academic and political needs, which allows for this study the adoption of the sustainability approach as a construct in the linkage and the perception of the productive sector for its participation in the AST and its impact on the training of graduates when considered in the curriculum design, the above is supported by statistical representation.

Box 1

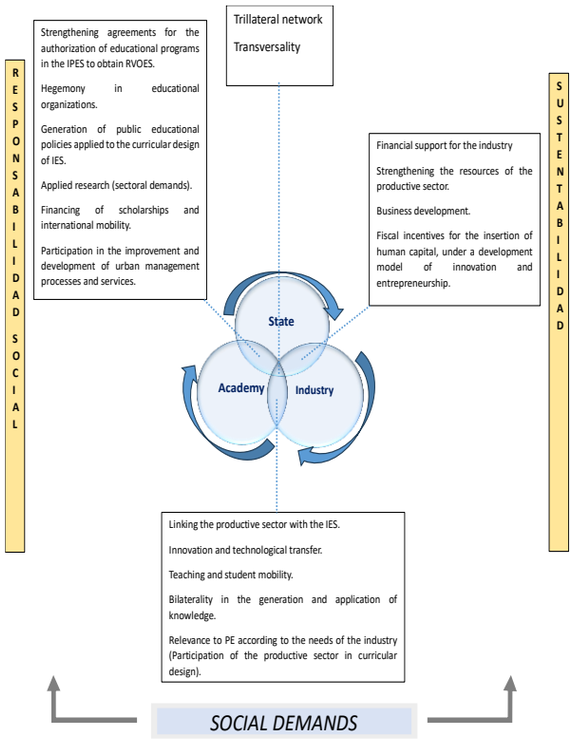

Figure 1
Triple Helix Model
Source: Antonio & Treviño (2018), Based On Etzkowitz, H., & Leydesdorff, L. (1997.

Literature Review

There are organizational models, which according to the needs of the company, it is necessary to use and can be modified, considering for its adaptation to its own system.

The knowledge that its staff brings, as well as key elements that allow a successful implementation, in this regard Velasquez C. (2005), considers the situational analysis, intervention and organizational learning, which establishes a dynamic of organizational change, considering learning as one of the factors.

This is why micro and macro environmental phenomena influence and demand changes in already existing systems, models or processes, so that the participation of different disciplines is necessary to promote an articulation of knowledge that allows the generation of complex models.

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García (2000) establishes how models of enormous heuristic utility can be generated for the description and simulation of the relationship between micro social and macro social processes, applying his study to the interaction of MSMEs with HEIs through the use of statistical tools.

A sustainable model focuses on the objective of satisfying the needs of the present generation without compromising the ability of future generations to compensate for their own needs.

Bernal (2010) indicates that individuals, organizations and nations that do not invest in education and research will be left behind, dependent and marginalized, and education will cease to fulfill its social mission.

Society requires research professionals to solve the problems that arise in the interconnected and digital world, to work collaboratively and to take care of our environment (Osorio, 2022).

In the conceptualization of AST, Hanel del Valle (2004), states that it is a method that leads to the application of the most appropriate procedure to analyze the situation of an organization, either to identify a problem, risk or area for improvement, (González, 2016) states that a Situational Analysis of Work consists of conducting a workshop with academics, entrepreneurs and experts to determine the competencies, knowledge and attitudes that a professional must possess to perform successfully in the labor field and for the purposes of this article its scope will be in the interaction of MSME's with academia, CGUT (2017), establishes that to initiate the design and curriculum development by professional competencies, the AST is applied, to the productive sector with which the Technological Universities are linked.

Technological Universities, as part of their competency-based model, assume the importance of training students and promoting interaction with companies, depending on the line of business and size, they consider as a strategy the practical schools and internships according to each educational program, having the first approach with the participation for the development of the AST.

Nuñez (2011), considers that there must be a mutual collaboration between the company and the academy, favoring the satisfaction of the needs of both.

According to Escalante (2020) who cites Sarabia (2016) and García et al., (2017) consider that collaboration between universities and companies benefit the development of countries, the exchange of knowledge favoring the generation of technologies and innovations that favor both parties and society.

In this regard Yáñez (2015) mentions that macro and micro environmental aspects should be considered for the Situational Analysis of the company in his argument focuses on decision making and application to adapt the factors in your organization, in a very general way, likewise they consider the key element: Human capital as part of the analysis to be part of the company. Likewise, Cañas (1999) argues the need to use technologies to build knowledge, intertwining map design with technology.

For students as Reyes (2016), a cognitive structure must be generated in the concepts to be used, since only from this will not be found arbitrary relationships with the new concepts. Therefore, in the AST design, it is aided by areas such as administration, pedagogy, computer science and statistics, developing a brainstorming to subsequently develop the feasibility analysis, with the help of matrices to form each element or construct that covers not only knowledge but also skills, abilities, skills, attitudes and aptitudes, as Ortiz, et al. (2015) considers the use of tools such as portfolios that show the skills of a person, being useful for the collection of information in the development of the AST.

With respect to the Higher University Technician (TSU), it is integrated to the Technological University system in Mexico since its opening in 1991, by filling an existing gap in the industrial and service sector with middle management that involves operational processes with aspects of its training 70% practical and 30% theoretical, besides being consistent in being, knowing and knowing how to do, integrating to ICT enables to be a versatile, dynamic professional who responds to the needs of the environment, by developing sustainable schemes implies consistency in the formation of competencies and using resources efficiently.

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This involves redefining the teaching-learning processes, as well as global perspectives to promote changes in future professionals and the application of knowledge in an environment of innovative transformation (Martínez, 2023).

The paradigm of sustainable development must become an unavoidable guideline for technological development, not to prevent or discourage it, but to accompany it, setting quality standards (Ferrer et al., 2023).

In the technological aspect, Tamayo (2022) comments that social networks have been a platform for sharing links and have motivated higher education institutions to implement networking and monitoring strategies in institutional communication due to the ease of reaching an infinite audience.

In addition, García-Arce et al. (2021) mentions that Higher Education Institutions (HEI) have a fundamental role as forgers of human beings committed to the environment, and interested in improving their quality of life, through the precepts of sustainability.

Methodology

It is of utmost importance that a company that provides a service must think customer-oriented if it wants to ensure its success.

That is why the purpose of this work is to obtain direct information from industrial consultants regarding ASTs and to analyze such information with basic and multivariate statistical techniques that allow identifying possible relationships between non-metric variables through the application of logistic regression. The challenge is focused on establishing strategies through which industrial advisors and ASTs are more efficient for the benefit of students considering the new demands of digital environments and their application in the generation of sustainable projects.

Logistic regression is a special form of regression in which the dependent variable is a dichotomous (binary) non-metric variable, also known as logit analysis Hair Joseph & Anderson Rolph (1999), where qualitative variable models are used.

This variable will reflect the choice made by an individual, which in this case will be each industrial consultant, according to a series of explanatory variables, hence it can be said that this type of model seeks to analyze, as far as possible, the answers given by each specific individual.

The dependent variable is dichotomous and will therefore follow a binomial probability distribution and its variance will not be constant. As a consequence, the regression errors will also be distributed as a binomial (not normally) and heteroscedasticity will be present, so logistic regression was developed as an alternative to linear regression applicable to these circumstances. For the purposes of this research, a quantitative research was applied, STATA 12 software was used as technological resources, and 465 surveys were applied in the different states to industrial advisors, who are the representatives of each company of the productive sector (MSME's) in which stays of UTCV's educational programs were carried out, performing 1 pilot test and after that the survey to be applied in its final version 2017 was validated, considering the variables of linkage, productive sector, IES, AST and public policies.

Results

For the analysis of the results, applying statistical analysis, each one is presented with the corresponding support: Specification of the Logistic Regression Model: According to the association results of the survey of Industrial Advisors, the following logistic regression model was found

$$P_i = (Y_i = 1|X_1, X_2, X_3, X_4) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\beta_3 X_3)}} \quad (1)$$

The model explains the probability that a person: Where $Y_i = anasit$: es the binary response variable that assumes the following values:

$$Y_i = \begin{cases} 1 = \text{If the industrial consultant has heard of the situational analysis of the job;} \\ 0 = \text{If the industrial consultant has not heard of the situational analysis of the job.} \end{cases}$$

The following are the set of independent variables that explain the likelihood that the company where the student stays is aware of the situational analysis of the job

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$X_1 = Buy$: *is a binary variable that assumes the following values*:

$X_1 =$ { 1 = If the industrial advisor is aware of the educational programs offered by UTCV;

0 = If the industrial consultant does not know them.

$X_2 = modcomp$: is a nominal binary variable that assumes the following values:

$X_2 =$ { 1 = Whether the industrial consultant is familiar with the competency-based educational model;

0 = If the industrial consultant does not know you.

$X_3 = caroies$: is a polychotomous variable on an ordinal scale that answers the question: How expensive is it for the company to collaborate with the Institute of Higher Education?

$X_3 =$ { 5 = Strongly agree;
4 =Agree;
3 =Disagree;
2 = Indifferent;
1 = Don't know.

$X_4 = polpub$: is an ordinal scale polychotomous variable that describes the industrial consultant's perception of whether public policies should be generated to propose mechanisms and tools to ensure pertinence, relevance, efficiency and equity..

$X_4 =$ { 5 = Strongly agree;
4 =Agree;
3 =Disagree;
2 = Indifferent;
1 = Don't know.

Non-parametric tests of association between the response variable and the independent variables, as part of the process for choosing the variables and specifying the model.

The following table shows the results of applying the Chi-square test of the response variable with each of the independent variables, as well as the value of the contingency coefficient to observe the degree of association between the variables.

Results of association of the response variable anasit and the nominal independent variables.

Box 1

Table 1

Results of association of the anasit response variable and the nominal independent variables

	Chi-square	Degrees of freedom	P-value α=5%	H0: Independence	Cramer's V contingency coefficient
Buy	17.116	1	0	Rejected	0.1919
Modcomp	23.783	1	0	Rejected	0.2262
Caroies	13.917	4	0.008	Rejected	0.173
Polpub	11.667	4	0.02	Rejected	0.1584

According to Table 1, the following statements can be deduced: There is statistically significant evidence according to the Chi-Square test what; the knowledge that industrial advisors have about job situational analysis -whether they have heard of the topic or not- is associated with the knowledge that advisors have about the educational programs offered by UTCV along with whether they know something about the competency-based educational model or if they know about it;

On the other hand, industrial advisors' knowledge about job situational analysis is also associated with industrial advisors' perception of how expensive it is for the company to collaborate with a higher education institution, as well as the latter's perception of whether public policies should be generated to propose mechanisms and tools to ensure pertinence, relevance, efficiency and equity. According to Cramer's V contingency coefficient, the variables are in a weak degree of association as both are close to 0.2, however, this does not prevent the variables from being associated as the tests show, in the case of caroies and polpub the association is even lower. The following image shows the results of the logistic regression model obtained in STATA 12.

Box 2

Table 2

Results of the model in STATA12

.

Logistic regression **Number of obs=465**
Log likelihood=-235.80236 **LR chi2(4)=48.60**
Prob > chi2=0.0000
Pseudo R2=0.0934

anasist	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Buy	0.7255	0.22903	3.17	0.002	0.27657	1.174339
modcomp	0.9899	0.2611	3.79	0.000	0.4782	1.501676
caroies	0.3604	0.14802	2.44	0.015	0.07034	0.6505519
polpub	0.3774	0.1632	2.31	0.021	0.05756	0.6972862
_cons	-4.7586	0.85238	0.02	0.000	-6.4291	-3.088031

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As can be seen in Table 2, the overall significance test from the Chi-Square test is significant, with a p-value equal to 0.000, which implies that the set of independent variables does exert a simultaneous overall effect on the response variable. According to the signs of the coefficients, each of the variables is positively associated with the probability that the assessor has knowledge about the situational analysis of the job, so the model is specified as follows:

$$P_i = (Y_i = 1|X_1, X_2, X_3, X_4) = \frac{1}{1+e^{-(-4.7585+0.7254X_1+0.9899X_2+0.3604X_3+0.3774X_4)}} \quad (2)$$

The greater the industrial counselors' knowledge about the educational programs offered by UTCV, the greater the probability that the industrial counselor knows about situational analysis;

If the advisor knows about the competency-based educational model, the higher the probability that he/she knows about situational analysis of the job.

The higher the perception of how expensive it is for the company to collaborate with a higher education institute, the more likely it is that he/she knows about job analysis;

The greater the perception of the industrial consultant about whether public policies should be generated to propose mechanisms and tools to ensure pertinence, relevance, efficiency and equity, the greater the probability that he/she will have knowledge about situational job analysis.

Box 3

Table 3

Results of the Wald test for individual significance

	Chi-cuadrado	Degrees of freedom	P-value α=5%	H0: Independence
compro	10.03	1	0.0015	Rejected
modcomp	14.38	1	0.0001	Rejected
caroies	5.93	1	0.0149	Rejected
polpub	5.35	1	0.0207	Rejected

According to the Wald tests of individual significance, all variables exert a partial and positive effect on the probability of response, as shown in Table 3.

Box 4

Table 4

Marginal Effects - Scenario 1-scenario 1-

Marginal effects after logit
y=Pr(anasit) (predict)
=0.65614998

Variable	dy/dx	Std. Err.	z	P>|z|	[95 %	C.I.	X]
Buy*	0.175957	0.05539	3.18	0.001	0.067	0.285	1
modcomp*	0.241252	0.06292	3.83	0.000	0.118	0.365	1
caroies	0.081323	0.02554	3.18	0.001	0.031	0.131	5
polpub	0.085153	0.03583	2.38	0.017	0.015	0.155	5

Table 4 shows the results of carrying out the calculation of the probability that an industrial advisor knows about job situational analysis when:

The industrial assessor knows about the curricula offered by UTCV;

The industrial assessor knows about competency-based educational programs;

The advisor is of the opinion that it is too expensive to collaborate with an institute of higher education and;

When the advisor fully agrees that public policies should be generated to propose mechanisms and tools to ensure pertinence, relevance, efficiency and equity.

According to the pre-established conditions the probability is approximately equal to 0.7, which can be considered as a very favorable probability.

According to the values resulting from the partial derivatives of the model, the variable that has the greatest impact on the probability of response is: if the industrial consultant knows the competency-based education model, this increases the probability by almost 24%.

Discussion

The General Coordination of Technological Universities regulates the use of the AST as an instrument to determine the elements that, according to the competency-based model, contribute to the curricular design of the proposed educational program, in addition to generating, by its nature, the interaction between HEIs and companies.

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However, with the statistical analysis, it was shown that for synergy to exist, both in the company and in the IES, the industrial advisor must have knowledge of the competency-based model and the AST. Therefore, it will be important to establish communication channels to generate actions for the participation of subjects that strengthen the Situational Analysis of Work and relevance in educational programs.

In this regard Bautista (2014) emphasizes the quadruple helix with the additional participation of the social sector to strengthen the linkage, although more subjects are being considered to promote the interrelationship, the ideal is to work with the communication channels that allow to generate and strengthen according to the role of the participants and how they could intervene for the design of the curriculum considering their own strengths.

Although the use of AST does not consider relevant aspects such as the knowledge of the participants in the competency-based model, as well as its applicability in the particular higher education institutions, it does have an impact on the contributions that are particularly limited to the knowledge, however, the participation of the productive sector in coordination with the authorities is necessary for the HEIs to carry out their processes in order to obtain the requirements for the official recognition and validity of their study programs, being a problem for the HEIs the assistance and participation in the elaboration of the AST's, due to the process involved in their development.

The use of statistical tools has been used as a means for the generation of models that allow the optimization of resources, quality, processes and decision making, however, in the interaction of research, academia, government and the productive sector as a whole, there is a lack of statistical models that strengthen their processes in this interaction. It is worth mentioning that AST focuses on human “capital”, being the future graduate who at the end of his studies will achieve the objective of his educational program according to its curricular design and the discourse given by Pariente (2010), in which he alludes not only to the participation of the teacher as a key piece in the construction of a hidden curriculum, but also to the educational situation in Mexico and the participation of the Government in the generation of public policies.

However, there is a gap in the interaction of the productive sector with Higher Education Institutions, as well as of tools and processes that help in strengthening the academic activities to be developed between both subjects, because although, according to Taipe (2015) establishes the elements to consider for a situational analysis of the company, they are not applied from a situational view of work and its application for the curricular design of educational plans and programs.

Conclusions

It was determined that through the use of statistical methods, in addition to the validation tests used in the survey, there is a correlation not only in the interaction of industrial consultants, but also in the knowledge of the competency model, the participation in the AST of MSMEs and the need to create public policies that allow interaction between the two.

In the results of the survey applied, it is perceived that the industrial consultants, not knowing the educational programs that the Educational Institution has, break with the interaction because there is no motivation of the company to generate a link with the academy, therefore, there is no participation in the AST, but it does consider necessary the intervention of the government to generate the linkage.

Therefore, by statistically testing all the elements that affect both external and internal, this allows strengthening the AST Model in such a way that the interaction of subject variables is demonstrated in the validation of the items and the probabilities that are favorable for the generation of the proposal.

Finally, actions will be developed to strengthen the Situational Analysis of Work, not only for the creation of educational programs and feasibility studies, but also to consider the phenomena that have repercussions for its pertinence and relevance in the decision making of organizations, as well as in the sustainable strategies that higher education institutions work with academic projects in conjunction with companies to comply with regulations that must be respected in the care of the environment, generation of sustainable projects, innovation and jointly achieve sustainable development in its different dimensions.

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Declarations

Conflict of interest

The authors declare that they have no conflict of interest. Neither have any financial interest, nor personal relationships that could have seemed to influence the development of this article.

Authors' contributions

Hernández-Peralta, Alejandro De Jesús: Methodology, analysis of results, and discussions.

Antonio-Vidaña, Paula Rosalinda: Title of the article, context, state of the art, methodology, analysis, development, conclusions, references, final review for acceptance.

Alcudia-Chagala, Lorena: Participated in the development of the state of the art, technological support and video for the virtual paper.

Rojas-Patiño, Nancy: Participated in the development of the state of the art, analysis of results and references.

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Abbreviations

HEI (Higher Education Institutions).
AST (Situational Analysis of Work)
MSME's (Micro, small and medium-sized enterprises).
CGUT (General Coordination of Technological Universities).
UTCV (Universidad Tecnológica del Centro de Veracruz).

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Article

Protected Natural Areas: A literary analysis of the Decrees of the Cerro de San Juan Biosphere State Reserve in Nayarit

Áreas Naturales Protegidas: Un análisis literario de los Decretos de la Reserva Estatal de la Biosfera Cerro de San Juan en Nayarit

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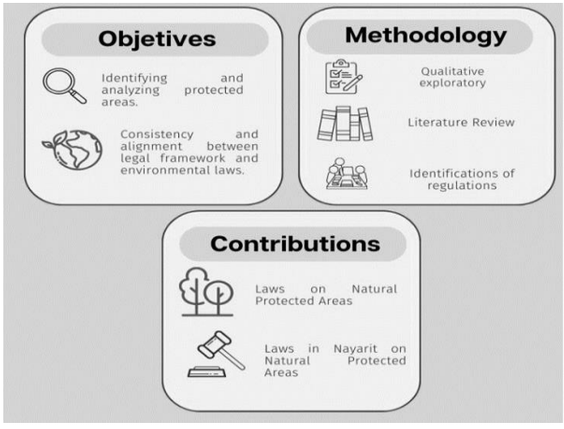
Abstract

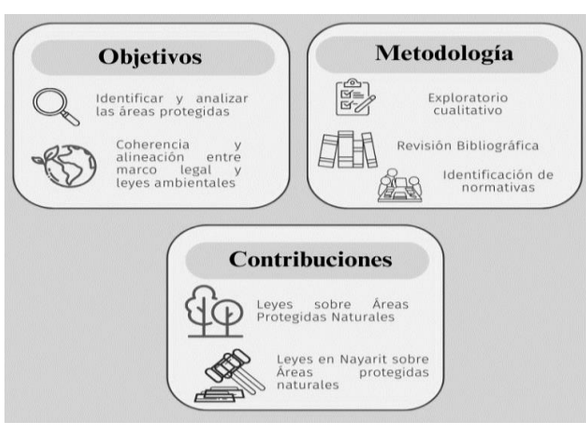
Protected Natural Areas (ANP) in Mexico are key to conserving biodiversity but face challenges due to poor management and violations of environmental laws, resulting in degraded habitats. The LGEEPA and state laws are essential for their conservation, requiring alignment of local governments. Collaboration among governmental entities, research centers, and society is crucial to establish ANP that comply with environmental policies. A study in 2023 analyzed environmental legislation and its impact, aiming to identify effective regulations for local communities. For effective conservation, ANP need appropriate management categories, zoning, and plans supervised multidisciplinarily. This approach will ensure efficient management aligned with national goals for conserving and restoring ecosystems in Mexico.



Protected natural areas, Environmental legislation, Biodiversity

Resumen

Las Áreas Naturales Protegidas (ANP) en México son clave para conservar la biodiversidad, pero enfrentan desafíos por mala gestión y violaciones a leyes ambientales, resultando en hábitats degradados. La LGEEPA y leyes estatales son fundamentales para su conservación, requiriendo alineación de gobiernos locales. La colaboración entre entidades gubernamentales, centros de investigación y la sociedad es esencial para establecer ANP que cumplan con políticas ambientales. Un estudio del 2023 analizó legislación ambiental y su impacto, buscando normativas efectivas para comunidades locales. Para una conservación eficaz, las ANP necesitan categorías de manejo, zonificaciones y planes adecuados, supervisados multidisciplinariamente. Este enfoque garantizará una gestión eficiente alineada con objetivos nacionales de conservación y restauración de ecosistemas en México.



Áreas Naturales protegidas, Legislación ambiental, Biodiversidad

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Introduction

Biodiversity is currently defined as all variation in the hereditary base at all levels of organization, from the genes in a local population or species, to the species that make up all or part of a local community, and finally in the communities themselves that make up the living part of the world's multiple ecosystems (Reaka-Kudla et al., 1997). One of the central elements in the strategy for biodiversity conservation in any country is the construction of a system of natural protected areas. The evaluation of the effectiveness of each area should be based on its contribution to conservation, but in the terms established by the designated management category (Íñiguez et al., 2014).

Natural Protected Areas (NPAs) are clearly defined geographic spaces, recognized and managed, through legal or other types of effective means to achieve the long-term conservation of nature and its ecosystem services and associated cultural values. In Mexico, NPAs are considered environmental policy instruments that seek the conservation of biodiversity, the sustainable use of natural resources and the maintenance of the environmental services they provide. Currently, the country has 182 federal NPAs, covering a total area of 90,839,521.55 hectares, which represents approximately 10.78% of the national territory (CONANP, 2023).

In the state of Nayarit, located in the western region of Mexico, there are several Natural Protected Areas that seek to preserve the natural and cultural richness of the state. Among the most outstanding NPAs in Nayarit are the Marismas Nacionales Biosphere Reserve, which protects important coastal wetlands and is home to a great diversity of aquatic birds; the Isla Isabel National Park, a volcanic island that is home to important colonies of marine birds and is a nesting site for the frigate bird; and the Sierra de Vallejo Biosphere Reserve, which protects tropical and temperate forests, as well as a great variety of endemic and endangered species of flora and fauna.

These NPAs, along with others present in the state, contribute to the conservation of Nayarit's natural heritage and provide important environmental services to the local and regional population (SEMARNAT, 2016).

Problem Statement

It is known that the mining industry has a negative reputation in environmental terms in developing countries (Muduli et al., 2013).

In very recent studies in the Mount Korok area, Juba, Central Equatoria State, South Sudan, according to studies by. Moilinga y Athian (2023) rock cutting and quarrying activities have been found to affect the environment in general, including the destruction and removal of local vegetation cover, particularly grass and non-woody herbaceous plants in low-lying areas. The physical crushing, excavation and removal of rocks produces high concentrations of particulate matter (dust), fumes, smoke and other gaseous substances, which negatively affect vegetation in the vicinity of quarrying areas.

Another similar study is found in Latin America, especially in Colombia, where there is a problem related to the extraction of stone materials in the Caño Camelias tributary of the Municipality of Guamal, located in the Department of Meta, in the Vereda Húmadea. In this case, it has been the inhabitants who have presented disagreements, due to the fact that the National Government, regional and local entities do not do anything to take care of the habitat, even though there are different regulations in force to address conflicts such as the alteration of the aquatic ecosystem.

This has resulted in the exploitation and expansion of mining concessions, which generates environmental and social conflicts in this area of the country, which increase due to the basins where deposits rich in stone materials are found. In this sense, the development of not only formal but also informal mining reflects an obsolete development in good mining practices proposed by the Ministry of the Environment (Aya Angie et al, 2022).

Based on the comments made in Colombia, it is important to generate more research to show to what extent and under what conditions environmental regulations can be established and applied to obtain positive environmental results and maintain competitiveness in the mining industry.

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To address this problem, Kusi-Sarpong, Sarkis and Wang (2016) propose the adoption of green practices in management, given that the activities that make up the mining production chain (exploration, extraction, processing and metallurgy) have serious environmental and social impacts, con important economic implications. For example, exploration involves the removal of vegetation, which causes erosion and habitat destruction; excavation, loading and transport of ore can disturb natural water flows or increase sediment loads in rivers; rock removal and excess water generate dust in the air.

These internal mining operations require careful attention and mitigation, which implies an extended responsibility from the producer to other stakeholders (customers, suppliers, society, government).

In Brazil, the study by Nepstad et al. (2006) analyzes land use conflicts in the Brazilian Amazon, focusing on the role of protected areas. The study found that protected areas can exacerbate land-use conflicts by restricting access to resources and creating competition between different interest groups.

Another study in Colombia, by Rodriguez and Van der Hammen (2012) examines land-use conflicts in the Serrania de Chiribiquete National Natural Park, Colombia. The study found that conflicts are driven by a variety of factors, including agricultural expansion, mining, and tourism. Similarly, in Peru, Naughton-Treves and Weber's (2009) study analyzes land-use conflicts in Tambopata National Reserve, Peru. The study found that conflicts are mainly caused by illegal logging, mining and agriculture.On the other hand, in India, the study by Nautiyal and Khera (2016) investigates land use conflicts in Corbett National Park, India. The study found that conflicts are mainly caused by the expansion of agriculture and grazing, as well as tourism and infrastructure development. And in South Africa, the study by Biggs and Rogers (2000) examines land-use conflicts in Kruger National Park, South Africa. The study found that conflicts are caused mainly by agricultural expansion, grazing and tourism.

For its part, Mexico has an immense natural wealth of animal species, flora, precious woods, and reefs, among others.

On the road to economic growth and development, the country has created a series of regulatory guidelines on the environment, in addition to its adherence to international treaties and agreements, thus ensuring a healthy environment. These indicate how to use natural resources, the timeframe, who can do so, the penalties and responsibilities in the event of non-compliance, as well as the obligation to restore the damage caused (Globalstd, 2023).

In this sense, in Mexico, the General Law of Ecological Balance and Environmental Protection identifies Natural Protected Areas (LGEEPA) as: “The areas of the national territory over which the nation exercises sovereignty and jurisdiction, in which the original environments have not been significantly altered by human activity, or whose ecosystems and integral functions require preservation and restoration” (DOF, 2012).

The use of natural resources and economic activities in these NPAs are subject to regulations through various legal frameworks, also known as “environmental legislations” or “Eco laws”, as indicated by (Castro-Salazar & Tovar-Cabañas, 2018). At the federal level, the LGEEPA is the main legal framework, while, at the state level, the State Environmental Laws of each federative entity, along with decrees, regulations and norms, play a crucial role in their regulation. Throughout the evolution of human beings and their progress in the scientific, industrial and economic fields, the imperative need to establish rules has arisen, this with the objective of preventing an imminent collapse in itself. This has led to the development and use of regulatory standards around the world and in various spheres, covering aspects such as health, economics and human rights.

However, having a defined and robust legal framework does not always guarantee effective representation of NPAs, which puts both environmental protection and sustainable development at risk. It is important to note that there is uncertainty about the alignment of local jurisdiction NPA decrees with the requirements of State Environmental Laws. In addition, it is uncertain whether the local legal framework has fully adhered to the guidelines of the LGEEPA in terms of establishment and nomination of state NPAs.

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The purpose of the present study was to analyse whether current environmental legislation facilitates an adequate representation of NPAs in the state, within the decrees established for the conservation and restoration of the Cerro de San Juan biosphere state reserve area, which is located in the state of Nayarit. This was achieved through two main approaches:

(1) Identifying the key characteristics of the NPAs under local jurisdiction, as established in the decrees, and

(2) To assess the coherence between the legal framework of these local decrees and the State Environmental Laws and the LGEEPA, in terms of the creation of NPAs.

Research Question

Based on the problem posed, one main research question and two secondary research questions can be established.

Main

To what extent does the current environmental legislation contribute to an adequate representation of the Natural Protected Areas (NPAs) in the state of Nayarit, specifically in the area of the Cerro de San Juan Biosphere State Reserve, through the decrees established for its conservation and restoration?

Secondary

1. What are the key characteristics of the NPAs of local jurisdiction in the state of Nayarit, as established in the decrees for the conservation and restoration of the Cerro de San Juan Biosphere State Reserve area?

2. How is the coherence between the legal framework of these local decrees and the State Environmental Laws and the General Law of Ecological Balance and Environmental Protection (LGEEPA) evaluated in terms of the creation and management of NPAs in the state of Nayarit?

These questions will guide the research towards a detailed analysis of environmental legislation and its impact on the protection and management of natural protected areas, focusing on a specific but relevant case to understand the overall picture in the state of Nayarit.

Theoretical framework

The Ministry of Environment and Natural Resources (SEMARNAT) is the government agency whose fundamental purpose is to establish a State policy of environmental protection, which reverses the trends of ecological deterioration and lays the foundations for sustainable development in the country, in conjunction with the National Council of Protected Natural Areas (CONANP), which also aims to conserve Mexico's natural heritage through the Protected Natural Areas and the Regional Sustainable Development Programmes in Priority Regions for Conservation (CONABIO, n.d.). (CONABIO, n.d.). Environmental legislation is a set of treaties, conventions, statutes, laws and regulations; its main objective is to regulate the interaction between humans and the rest of the components of the natural environment. Among its main areas are pollution control, remediation and conservation of resources and environmental management (Hernández, n.d.).

Taking into account all these factors, the need arises to create laws that can generate the preservation and restoration of the ecological balance. In Mexico there are different laws that help to regulate all environmental aspects, some of them are the following: (a) General Law on Ecological Balance and Environmental Protection, (b) Law on National Waters, (c) General Law on Sustainable Forest Development, (d) General Law on Wildlife, (e) Law on Sustainable Rural Development, (f) General Law for the Prevention and Integral Management of Waste, (g) Law on Biosafety of Genetically Modified Organisms, (h) Law on Organic Products, (i) General Law on Sustainable Fisheries and Aquaculture, (j) Law on the Promotion and Development of Bioenergy, (k) Federal Law on Environmental Responsibility, (l) General Law on Climate Change (CESE, 2021). According to Art. 44 of the General Law on Ecological Balance and Environmental Protection (LGEEPA), Natural Protected Areas (NPA) are areas of the national territory and those over which the Nation exercises sovereignty and jurisdiction, in which the original environments have not been significantly altered by human activity, or whose ecosystems and integral functions require preservation and restoration, shall be subject to the regime provided for in this Law and other applicable regulations (CONANP, 2023).

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The underlying purpose of the General Law on Ecological Balance and Environmental Protection is to conserve the biological diversity represented by the various ecosystems, ensuring the balance and continuity of evolutionary and ecological processes, without essentially modifying their characteristics. These areas are managed by means of a policy instrument that has a more precise legal definition, regulating activities according to the normative framework established by the General Law on Ecological Balance and Environmental Protection. In addition, they are subject to specialised regimes of protection, conservation, restoration and development, categorised according to the provisions of the CONANP legislation (CONANP 2023).

Complementarily, Natural Protected Areas (NPAs) aim to monitor the sustainable use of resources within the area to ensure the preservation of specific flora and fauna. They also aim to promote research and study of these ecosystems to generate knowledge and facilitate their sustainable use. NPAs can have social, economic, cultural and educational potential, and proper tourism management can contribute to the economic, social and environmental development of the territory and local communities (De Souza & Franco, 2023; Blanco-Cerradelo et al., 2022).

The forestry profession plays a crucial role in preserving the health and stability of forests within protected areas, including monitoring and implementing environmentally friendly protection measures. Protection of natural areas is essential to prevent biodiversity loss and habitat degradation, and proper organisation of protection measures is necessary to minimise negative impacts on nature and ensure abundance and sustainable use of natural resources (Zyablova, 2022). The effectiveness of protected areas can be assessed using methods such as large-scale outcome evaluation, which allows monitoring changes over time at a large scale (Rivarola et al., 2022).

Study area

The study area is the Sierra de San Juan. Seven natural vegetation units are recognised: a) tropical sub-deciduous forest, b) mountain mesophyll forest, c) oak forest, d) pine forest, e) mixed oak-pine forest and f) secondary scrub.

It was declared as a Conservation and Ecological Balance and Environmental Regeneration Reserve 'Cerro de San Juan', on October 28th, 1987, by the Government of the State of Nayarit, more for conjunctural situations than with scientific knowledge bases, for its delimitation only the elevation 980 m above sea level was used as a criterion; in the municipalities of Tepic and Xalisco. It was reclassified as a Biosphere Reserve by decree published on 18 October 2003, where its delimitation was modified to adjust it to the Tepic Urban Development Plan 2000-2020, which contemplates urbanisation up to 1080 m above sea level, in addition to excluding large areas of crops that surrounded the previous elevation. Its management programme was published in December 2008; subsequently, on 18 June 2011, in order to exclude the exploitation of stone materials from the Reserve, its polygon was reformed by decree, reducing its surface area to 19,912 hectares (P.O.E.N., 2019).

Box 1

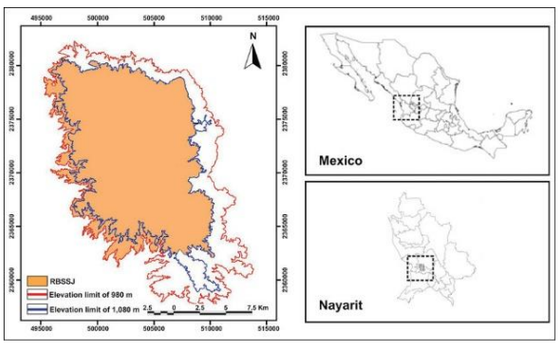

Figure 1

Location of the state biosphere reserve sierra de San Juan in the sierra San Juan Nayarit.

Modified from González (2010)

Methodology

Approach and type of study, relevance of the research. This is an exploratory study of a qualitative nature, it is a documentary research and according to the sources consulted it is of the bibliographic type; methodologically speaking, the following was complied with: Through specialised databases and consultation spaces such as official websites, where information was found regarding the problem under investigation, on how current environmental legislation contributes to an adequate representation of the Natural Protected Areas (NPA) in the state of Nayarit.

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Specifically in the area of the Cerro de San Juan biosphere state reserve, through the decrees established for its conservation and restoration, a survey of sources was carried out in which first the available texts on this subject were consulted and a selection of the most specific documents possible was made.

This implied carrying out a bibliographic review, in which we sought to identify the regulations and social, political and environmental impacts related to the exploitation of Natural Protected Areas. In addition, we looked for the best way to take advantage of them and adapt them to the needs that arise, for the benefit of the localities, as this is in great demand; we also sought to define strategies that would allow for the adequate development of these activities through the environmental regulatory norms and the benefit of the interested parties. The importance of developing the study is that it will facilitate the identification of the possible impacts of non-compliance with current regulations, due to the opacity in the application of the laws by the state government. This leads to the generation of economic, political and social conflicts.

Subsequently, a review of sources was carried out with the aim of determining the existing material on the topic under investigation, thereby filtering the content, discarding that which was not useful for the present research; the materials were then selected in detail, finding mainly decrees, legal frameworks and regulatory laws, with which a thorough review of the selected material was carried out, but this time taking textual quotations that allowed the arguments that support the present study to be mapped out.

In order to locate the necessary bibliographic documents, various sources of documentary information were used. This in the course of June to December 2023, a bibliographic search was carried out in internet search engines, such as Google Chrome, Google academic, as well as in the databases of the official newspaper of the state of Nayarit, laws and constitutional decrees of Mexico and repositories of different universities, as well as in physical books of authors, using key terms such as decrees, environmental legislation, natural protected areas, theses and other related articles of reading and criticism.

Likewise, for the bibliographic review, studies were selected that would provide information on the formal aspects necessary to carry out a critical reading of documents and the steps to carry out a bibliographic review. To achieve this, digital databases from different universities were used, such as: the Autonomous University of Nayarit, Autonomous University of Ciudad Juarez, Autonomous University of Aguascalientes, Cooperative University of Colombia, as well as the official newspaper of the state of Nayarit to search for the different norms and laws that govern the environment in Mexico.

Development and discussion

To define the limits of the reserve, the officials did not base themselves on a justification study that would highlight the value of the biodiversity elements, the landscape or the most outstanding natural processes; instead, the criteria used for its delimitation was the area that would be included above the altitude of 980 m above sea level, which meant that areas with human settlements such as Xalisco, Tepic and El Ahuacate were included, as well as large areas of cultivated land.

With this initiative, in 1987 Nayarit came to possess two decreed protected areas, one as a national park (Isla Isabel) and the other as a state ecological reserve (Sierra de San Juan), covering barely 1% of the state's territory (González Flores, 2010).

It is important to point out that the Sierra de San Juan has traditionally been subject to economic exploitation based on activities such as crop and perennial agriculture, exploitation of forests, livestock and extraction of materials for construction; all these activities have been developed without any vocational planning which, to date, has resulted in the alteration and ecological imbalance of the environment, and this is expressed in the depletion of water tables, deforestation, forest fires, soil loss, atmospheric and water pollution and deterioration of the landscape in general.

All this has direct repercussions on the decrease of the region's floral and faunal biodiversity, and indirectly, on the alteration of the population of Tepic, the state capital (Bojórquez Serrano & López García, 1995).

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According to the Municipal Planning Institute of Tepic (2000), the third function of the city as a mining centre has appeared in the last century, due to the proliferation of construction material mines in the San Juan hill, a function that has been consolidated since the exhaustion of the 'Loma del Toro' mine and the accelerated demographic growth that Tepic has had in comparison to the rest of the State.

The analysis of the coherence between local and federal regulations in the creation of Natural Protected Areas (NPAs) in South-Southeast Mexico revealed that, although most of the decrees partly follow the guidelines of the State Environmental Laws for the establishment of local NPAs, there are notable disagreements, especially with regard to the nomenclature of the management categories as compared to what is stipulated in the state laws.

This is often due to a lack of knowledge or willingness on the part of local authorities to implement effective environmental policies, resulting in hasty or inappropriate categorisation decisions, influenced by political interests or governmental plans that may compromise the management and sustainable use of these areas.

Conclusions

In order to answer the main research question: To what extent does the current environmental legislation contribute to an adequate representation of the Natural Protected Areas (NPA) in the state of Nayarit, specifically in the area of the Cerro de San Juan biosphere state reserve, through the decrees established for its conservation and restoration?

It is necessary to answer the secondary questions: What are the key characteristics of the NPAs of local jurisdiction in the state of Nayarit, as established in the decrees for the conservation and restoration of the Cerro de San Juan state biosphere reserve area? And how is the coherence between the legal framework of these local decrees and the State Environmental Laws and the General Law of Ecological Balance and Environmental Protection (LGEEPA), in terms of the creation and management of NPAs in the state of Nayarit, evaluated?

The current environmental legislation in Mexico, particularly the General Law on Ecological Balance and Environmental Protection (LGEEPA) and the State Law on Ecological Balance and Environmental Protection of Nayarit (LEEEN), provides a legal framework for the creation and management of Natural Protected Areas (NPAs). The Decree declaring 'Cerro de San Juan' as a State Biosphere Reserve, published in the Official Gazette of the State of Nayarit on 22 July 2010, establishes the basis for the conservation and restoration of this important natural area. The decree defines the objectives of the reserve, which include the protection of biodiversity, the conservation of ecosystem services and the promotion of sustainable development in the region. It also establishes the reserve's zoning categories, which include core zones, buffer zones and transition zones.

Consequently, the creation of the Cerro de San Juan State Biosphere Reserve is an important step towards ensuring the long-term protection of this valuable ecosystem. However, it is essential that the state government and responsible authorities effectively implement and enforce the provisions of the decree to ensure that the reserve meets its conservation objectives. The impact of mining activities on the environment goes beyond extraction, generating serious consequences such as deforestation, habitat destruction and air and water pollution. These activities pose a significant threat to biodiversity and ecosystem health, requiring strict regulations and enforcement mechanisms to mitigate their adverse effects.

However, the alignment of state environmental laws with the LGEEPA is not only crucial, but imperative to ensure a coherent and comprehensive approach to conservation efforts. By harmonising state regulations with national environmental policies, a unified framework can be created that promotes sustainable practices, protects natural resources and effectively mitigates environmental degradation.

It is recommended that optimising Natural Protected Areas to benefit local communities involves a multi-faceted approach that goes beyond legal compliance.

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It requires the development of tailored strategies that consider the socio-economic context, cultural particularities and ecological sensitivities of each region.

Collaboration between government agencies, research institutions and civil society is essential to design and implement conservation initiatives that not only protect biodiversity, but also support community well-being and sustainable development.

Consequently, in order to establish an effective conservation policy through state NPAs, it is imperative that governments develop criteria in line with the LGEEPA, ensuring that decreed NPAs have adequate management categories, zonings aligned with their objectives and well-defined management plans.

The Decree declaring the 'Cerro de San Juan' Biosphere Reserve as a State Protected Natural Area establishes the following key characteristics for NPAs of local jurisdiction in the state of Nayarit: (a) Conservation objectives: NPAs must establish clear and specific objectives for the conservation of biodiversity, ecosystem services and cultural values; (b) Zoning categories: NPAs should be divided into different zoning zones, each with its own objectives and use regulations; (c) Management plans: NPAs should have management plans that describe the actions and strategies needed to achieve conservation objectives; (d) Social participation: Local communities and other stakeholders should be involved in the planning and management of NPAs; (e) Financing: NPAs should have sufficient sources of funding to cover management and conservation costs.

In this sense, the legal framework of local decrees for the creation and management of NPAs in the state of Nayarit is generally consistent with the State Environmental Laws and the LGEEPA. However, there are some areas where local decrees could be strengthened to ensure greater alignment with the federal legal framework. For example, the LGEEPA establishes that NPAs must have management plans approved by the Ministry of Environment and Natural Resources (SEMARNAT). However, the Decree declaring 'Cerro de San Juan' a Protected Natural Area as a State Biosphere Reserve does not explicitly mention the need for a management plan.

Furthermore, the LGEEPA establishes that NPAs must have mechanisms for social participation in their planning and management. Although the Decree declaring 'Cerro de San Juan' a Protected Natural Area as a State Biosphere Reserve mentions the importance of social participation, it does not provide specific details on how this participation will be implemented. In general, the legal framework for the creation and management of NPAs in the state of Nayarit is sound and provides a basis for the long-term conservation of the state's natural resources. However, local decrees could be strengthened to ensure greater alignment with the federal legal framework and address the specific concerns of local communities and other stakeholders.

Finally, it is crucial to maintain constant vigilance in the declaration and management of NPAs. This requires collaboration between the federal government, state governments, research centres and civil society to carry out meaningful multidisciplinary studies and review environmental legislation. The process of declaring a NPA should start with the establishment of a clear conservation objective, to ensure its efficient management in accordance with the national policy of conservation and restoration of ecosystems in Mexico.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Authors' Contribution

The contribution of each researcher in each of the points developed in this research, was defined based on:

Gómez-Pintado, Rocío: Contribuyó con la idea principal y la realización del proyecto, así como el primer borrador.

Zepeda-Martínez, Gabriel: Contribuyó con la revisión en redación y estilo, así como la revisión y modificación de citas y referencias, y finalmente la adaptacion al formato de ECORFAN.

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Enciso-Arámbula, Rosalva: Contribuyó con el asesoramiento en temas de sustentabilidad, estructura del artículo, normatividad y leyes vigentes en sustentabilidad.

Soto-Ceja, Edel: Contribuyó como asesor experto en temas de desarrollo Urbano, Sustentabilidad y preservación de áres protegidas.

Availability of data and materials

La disponibilidad de los datos y materiales se encuentran en posesión de los autores del estudio. Favor de comunicarse a gabrielzepeda@uan.edu.mx para obtener los datos.

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The research did not receive any funding.

Abbreviations

ANP	Áreas Naturales Protegidas
LGEEPA	Ley General de Equilibrio Ecológico y Protección Ambiental
LEEEN	Ley Estatal de Equilibrio Ecológico y la Protección al Ambiente

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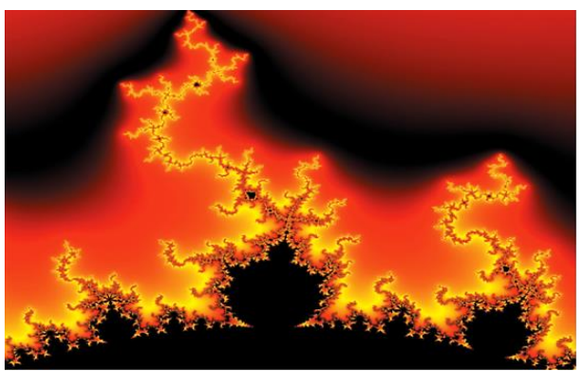

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The results shall be by section of the article.

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Author contribution

Specify the contribution of each researcher in each of the points developed in this research.

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Benoit-Pauleter, Gerard: Contributed to the project idea, research method and technique.

Availability of data and materials

Indicate the availability of the data obtained in this research.

Funding

Indicate if the research received some financing.

Acknowledgements

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Abbreviations

List abbreviations in alphabetical order.

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ANN	Artificial Neural Network

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