

Ariel Bernal Lima

Environmental diagnostic of municipality of zinacantepec, estado de méxico

COMPROBIDES, Dirección de Medio Ambiente, Ayuntamiento de Zinacantepec, Estado de México

Abstract

In the period 2021- 2023, technical tours were conducted as part of the Local Ecological Management of Zinacantepec to carry out the environmental diagnosis of the territory, in which soil degradation is present in the sub-basin of the Tejalpa River while the forest ecosystem in the Zinacantépetl Formation is in a process of feedback according to the General System Theory (GST), that is, recovery with a positive trend in the forest cover. The purpose of this research is to analyze the characteristics of the physical-geographical subsystem in order to determine the environmental conditions in the study area. In order to achieve the specific objectives, a methodology based on the evaluation of the disturbances in the balance of the environmental system was proposed, for which thematic cartography was obtained, as well as the state of evolution of the relief by means of matrices applied in field work. On the other hand, through COMPROBIDES, training sessions and working groups have been held to present multidisciplinary proposals that promote environmental protection based on the results obtained, in which processes of land use change, water erosion, deforestation, greenhouse gas emissions, water pollution and urban location in agricultural areas have been identified. It should be noted that knowledge of the geodynamics of geographic space has contributed to social and public participation for the preservation of natural resources.

Keywords: *diagnostic, SGT, evolution, multidisciplinary, contamination*

Sugerowana cytacja / suggested citation: Bernal Lima Ariel (2023). Environmental diagnostic of Municipality of Zinacantepec, Estado de México . *Annales Universitatis Paedagogicae Cracoviensis Studia Geographica*, 20, 29–38, doi: 10.24917/20845456.20.3

Introduction

The analysis of the environmental conditions of the municipality of Zinacantepec is derived from the diagnostic phase corresponding to the Local Ecological Management Program where in accordance with the provisions of the General Law

of Ecological Balance and Environmental Protection in Article 8, which includes the formulation and issuance of the program, as well as monitoring the use and change of land use, Article 20 BIS 4, which defines the criteria for determining environmental conditions, regulating land use outside population centers and establishing criteria for ecological regulation. On the other hand, Article 20 BIS 5 establishes the bases for the elaboration of such program, where there must be congruence between programs, geographic extension, specifications on land use and in case of extending urban development, it is required to refer to what is established in the ordinance, incorporate provisions of existing programs in the study area, coordinate mechanisms and the collaboration with State and Federal Secretariats when the territory is located within a Natural Protected Area.

The methodology has a participatory approach where the theoretical foundations are applied to the inhabitants of Zinacantepec to learn about the environmental conditions of the municipality from a theoretical and practical perspective. The difference that exists between case studies without cabinet work and multisectoral analysis applied to field tours is the validation of the characteristics, as well as the investigation of the transformation of the landscape from the scientific method and the influence that exerts between the human being on the existing ecosystems, with the goal of correcting the deficiencies of the public sector from the geographic investigation.

With the processing of data in the QGIS, ARCGIS and SNAP work packages, the results are represented graphically to know their distribution and changes in the landscape over time, since with these tools scenarios are created to perform a sampling to determine the diagnosis of environmental conditions, allowing multidisciplinary integration of remote sensing with other sciences in a direct way to collaborate with the development of new products, methodologies and incorporation of sub-branches in other disciplines for the interpretation of natural, social and economic events in the world.

Problem

Contaminated and weakened forests are susceptible to diseases and pests, which are part of the panorama that reflects the fragility and impossibility of the environment to recover its stability (Galicia et al., 2007). In this context, the localities located in the northwest and southwest of the municipality of Zinacantepec present a change in land use, that is, a transformation in the original vocation of the soil, since agricultural activity has expanded its zone of influence towards the coniferous forest, which reduces the environmental services provided by each forest species. Likewise, human settlements are a variable that has modified the cultivated area towards residential use. This transformation of the landscape causes erosion in crops and soil degradation due to the use of fertilizers, which leads to an acceleration of climate variability in the territory due to the absence of vegetation in the forest.

The influence of the social and economic subsystem on the natural environment directly affects the preservation of natural resources, so the towns of San Luis Mextepec, San Antonio Acahualco and San Juan de las Huertas are those that show

traces of environmental degradation in the soil as a result of the increase in demographic dynamics in a period from 2010 to 2023.

In terms of greenhouse gas monitoring, there is a shortage of updated information corresponding to the physical-geographic, economic and social characteristics in Zinacantepec, which requires the regionalization of priority areas and those areas with a high degree of environmental degradation. The weighting of attributes is a non-structural tool for the inhabitants to identify their current conditions in the geographic space, which are generated through the correlation that exists between natural resources, economic activities and demographic dynamics in rural or urban localities according to the aptitude of land use, as well as the public policies established for sustainable development in the study area.

Methodology

To fulfill the purpose of this research, three phases were carried out, which consisted of characterizing the natural, social and economic subsystem, updating the cartography, weighting the variables that influence the development of each sector in the territory and evaluating the conditions of the geographic space in a period from 2021 to 2023. This information was obtained through field visits, verification of cartographic units, meetings and workshops with the inhabitants, as well as the calculation of indicators for the knowledge of landscape transformation using QGIS 3.32, SNAP 8.0 and ARCGIS 10.5 work packages.

Characterization of subsystems

The physical-geographical analysis of the municipality of Zinacantepec was carried out in accordance with the conditions of the territory explained by Bernal (2022) and the criteria postulated in Article 68 of the Regulations of the General Law of Ecological Balance and Environmental Protection, which establishes the minimum sections for the study of restoration zones in a Natural Protected Area, in this case, the Nevado de Toluca Flora and Fauna Protection Area.

This update of the variables involved in this study was accomplished through the verification of cartographic units in the field, supervised classification of satellite images, Inverse Distance Weighting (IDW), TIN (Triangulated Irregular Network) interpolation, calculation of the slope of the terrain, as well as the representation of the order of fluvial currents. In the case of lithological and geomorphological units, the classification proposed by Mooser et al., (1996) was taken up again, as well as the regionalization of Espinosa et al., (2014) where he postulates that the Formación Zinacantépetl is a filling of fluvial valleys associated with recent deposits of blue-gray ash, burning clouds and ash showers corresponding to the Quaternary with a dating of 60 kiloyears. It should be noted that for the explanation of the processes involved in the transformation of the relief, the General System Theory (GST) proposed in Germany by Carl Troll in 1949 (cited in Espinosa, 2009), which establishes that the geographic space is composed

as a whole integrated by subsystems that allow its functioning, i.e., the input and output of energy in the system.

Environmental attributes workshop

In the first session of the Technical Body of the Zinacantepec Management Committee, a workshop was held for the weighting of the attributes that influence the environmental sphere with the objective of identifying the importance of the variables of the natural, social and economic subsystem in the sectors established in the local ecological management. These results allow the foundations for the regulation of the land and its vocation to be established.

To achieve these actions, the main authorities of the Zinacantepec city council, representatives of society, heads of state and federal departments, ejidatarios and inhabitants of the localities with environmental problems met. The meeting was divided into 4 tables corresponding to the agricultural, forestry, urban and tourism sectors; these tables graphically identified the areas with less sustainability in the study zone. It should be noted that the contributions generated in these multidisciplinary roundtables are part of the process established for the generation of environmental management units, so that through this information the suitability of each sector is defined; the mapping and description of the scenarios in the territory as a tool for the consultation of subsequent research or related to the study area. Derived from the above, the general conditions in the territory by sector are as follows:

Agriculture: The introduction of crops in the protected natural area has caused the substratum in the fluvial currents to fall, increased CO₂ emissions, and loss of the forest's environmental services, which indicates a transformation in the relief, as well as the contamination of the surface soil horizon, in this case, of forest vocation.

Forestry: The forestry regionalization in Nevado de Toluca is an area that has an environmental policy of sustainable use of timber and non-timber resources, so there is a shortage of monitoring of extraction, deficiency in the management plan, illegal logging, as well as corn, potato, bean and oat crops.

Urban: The change of land use in the agricultural sector developed in the towns of San Juan de las Huertas, San Antonio Acahualco and San Pedro Tejalpa at the beginning of the sanitary emergency derived from SARS-COV-2 in April 2020, where the inhabitants began to build houses on their land as a consequence of the contingency and the scarcity of activities in the economic sector. The growth of population centers, and the development of economic activities in the secondary and tertiary sectors are factors that require an increase in the demand for services and coverage in the localities so that the connection between the territory increases the susceptibility to erosion in agricultural trails.

Once the workshop is over, the information obtained is presented, in which the areas with environmental problems are located as well as those that are a priority for the preservation of natural resources. These zones are represented in cartographic form for the generation of a preliminary map that allows regionalizing the evolution of the landscape and urban development on forest vocation soils;

in this case, the municipality presents irregular settlements in the Tejalpa and San Pedro rivers, increase of carbon and methane emissions in urban localities, water contamination as well as disturbances in the natural soil conditions in San Juan de las Huertas, San José Contadero and San Pedro Tejalpa.



Figure 1.1 Environmental attributes workshop in Zinacantepec

Source: Author's photograph (2021).

Variables Analysis

The next stage, after the desk work, begins with the validation of the environmental attributes through technical tours with the participants of the environmental attributes workshop to identify the evidence of each sector in the geographic space by means of observation, sample collection, measurement of morphometric parameters and data collection with the population attached to the verified sites.

The Integrated Waste Center located in the northern zone of Zinacantepec has a system that uses the emission of pollutants to transform them into biogas, although cell 8 specifically requires maintenance due to leachate leakage through gravity. As part of the activities carried out to mitigate soil degradation, vermicompost is produced and distributed to the towns of San Luis Mextepec and San Miguel Zinacantepec, where the consumption of fertilizers in the hazardous waste category has been reduced.

The flood plain is located under irregular settlements with housing in medium to very high levels of marginalization in San Pedro Tejalpa, El Cerro del Murciélago and San Antonio Acahualco, which have modified the course of the

riverbed by means of structural measures to prevent the river from overflowing and in a negative way as a channel that carries solid waste, as well as part of the local drainage system in an autonomous manner in the aforementioned localities.

The Consejo Municipal de Protección a la Biodiversidad y Desarrollo Sostenible (COMPROBIDES) has carried out actions and proposals for environmental protection such as environmental education workshops, sessions to address problems in the forest area, reforestations, expeditions to land with soil degradation and collaboration with the Greenhouse Gas Inventory as part of the Municipal Climate Change Action Program, where thematic cartography was generated that regionalizes the zones (industries, agriculture, energy and waste) that have increased their emissions in Zinacantepec, as well as the creation of living barriers that mitigate atmospheric contamination in the medium term in the municipal capital.

Results

Based on the thematic mapping, social participation and field verifications, as well as the technical tours corresponding to the Local Ecological Management Program, the following results were obtained:

The southern zone of San Juan de las Huertas shows a process of land use change where the pine-oak forest is occupied by corn, potato and bean crops, while the agricultural areas are used for housing. One of the causes of the deterioration of the forest ecosystem is due to anthropic intervention because the degradation of the surface soil horizon affects the geodynamics of fluvial erosion, so these morphological conditions condition the suitability of the soil due to the concentration of surface runoff and the exploitation of timber resources that increases the natural fragility of the soil and the geological substrate.

The Área de Protección de Flora y Fauna Nevado de Toluca has a recovery process west of Santa María del Monte (approximation to the original conditions of the territory) after the landslide occurred in 2011, so the functioning of the services of the vegetation cover (infiltration, soil retention and resistance to cutting in the geological substrate) is maintained through reforestation and natural extension of the oyamel forest.

In the western zone of San Antonio Acahualco, there is flooding from wastewater from the overflow of the Tejalpa River, which causes contamination and soil degradation in the crops located in the floodplain. These processes are caused by agricultural activity, fluvial erosion and lateral scour present in the fluvial valleys, since the evidence of these factors in the natural subsystem allows us to observe the stratigraphic cut (pumice and tuff) and the soil profile with a depth of 6 meters in the accumulative piedmont ramp.

During the rainy season (June to September), the main roads in the municipality of Zinacantepec have more than 75 mm of precipitation. On the other hand, the slope of the terrain is less than 3° with little possibility of infiltration due to the asphalt covering. The water flow is composed of precipitation of fluvial origin (surface streams to the northeast of the municipality) and rainfall, which has occasionally knocked down trees in an extraordinary way as shown in the Figure where this specimen caused damage to surrounding vehicles.



Figure 1.2 Forest recovery in Santa Maria del Monte

Source: Author's photograph (2023)



Figure 1.3. River valleys in San Juan de las Huertas

Source: Author's photograph (2022)



Figure 1.4 Urban tree falling in San Miguel Zinacantepec

Source: Valdez (2021)

Finally, it should be noted that the northern zone of Nevado de Toluca corresponding to the municipality of Zinacantepec shows fluvial erosion and weathering of the predominant rock as a result of the loss of vegetation cover, weakness of the substrate and temperature variability. It is also recognized that land use change is a conditioning factor for flood hazards because the urban location towards agricultural areas increases susceptibility to hydro-meteorological events and the loss of environmental services provided by the forest ecosystem. The advance of agriculture into the forest has caused fluvial flooding in the flood beds of the San Pedro and Tejalpa rivers, such as in the case of El Capulín, as well as the water reservoir in the towns of San Antonio Acahualco and San Pedro Tejalpa, which were affected in 2021.

Conclusions

It should be noted that knowledge of the natural, social and economic subsystem makes it possible to identify and determine the current conditions of the territory, so it is important to disseminate information on environmental problems and human intervention in the degradation of natural resources to the inhabitants of the study area in order to implement medium-term mitigation measures against climate variability in Zinacantepec.

In general, land cover change is a consequence of the interaction of human activities with the natural environment. Such changes indicate the impact of economic activities and the development of human communities on the territory and its resources, and make it possible to identify problems related to the sustainability of human activities. Spatial zoning and quantification of changes contribute to the characterization of the territory and the location of priority areas for attention, as well as to the establishment of corrective policies and the formulation of respective action plans for resource management.

Collaboration between institutions and the inhabitants allows social participation in the care, conservation, preservation, remediation, rehabilitation, and restoration in accordance with the provisions of Article 2.9 Section XXXIII of the Code for Biodiversity of the Estado de México. The follow-up of phases in the elaboration of programs is one of the purposes that contribute to the analysis of the environment from its processes and human activities that have deteriorated the natural resources. In this context, the interpretation of the origin or causes that transform the geographic space is fundamental for the evaluation of the municipality of Zinacantepec and the determination of the environmental conditions.

To conclude, the multidisciplinary proposals for environmental protection put forward by localities, city council members and professionals are part of the municipality's feedback for the execution of programs with trend scenarios that allow us to know the economic and social impact that environmental pollution has on the specific activities of the political-administrative demarcation.

References

- Arce, J., Macías, J., & Vázquez-Selem, L. (2003). The 10.5 ka Plinian eruption of Nevado de Toluca volcano, Mexico: Stratigraphy and hazard implications. *Geological Society of America Bulletin*, 230–248.
- Bernal Lima, A. (2022). *Peligros por inundación y remoción en masa en el municipio de Zinacantepec*. Toluca, Estado de México, Universidad Autónoma del Estado de México: TESIS Para obtener el Título de Licenciado en Geografía, .
- CC. Diputados Secretarios De La H. LIV Legislatura;. (2001). Libro Quinto, Del Ordenamiento Territorial de los Asentamientos Humanos y del Desarrollo Urbano de los Centros de Población. En C.D. Legislatura, *Código Administrativo Del Estado De México* (págs. 91–171). Toluca de Lerdo, México.
- CONANP. (2019). *Términos De Referencia Para La Elaboración De Programas De Manejo De Las Áreas Naturales Protegidas*. SEMARNAT.
- Espinosa Rodríguez, L. M., Balderas Plata, M. Á., & Baro Suárez, J. E. (2018). El relieve, factor para la génesis, desarrollo y gestión del riesgo. *Ciencia Ergo*, XXV. Obtenido de <https://www.redalyc.org/articulo.oa?id=10453975008>
- Espinosa-Rodríguez, L. M., Balderas-Plata, M. Á., & Cabadas-Báez, H. V. (2014). Caracterización Geomorfológica Del Área Natural Protegida Nevado de Toluca: Complejo de Volcanes Nevado De Toluca y San Antonio. *Biología y Química, Área I. Físico Matemáticas y Ciencias de la Tierra*, 6–14.
- FAO. (2015). *Objetivos de Desarrollo Sostenible*. Obtenido de La FAO y el post 2015: <http://www.fao.org/sustainable-development-goals/overview/fao-and-post-2015/es/>
- Galicia, L., García-Romero, A., Gómez-Mendoza, L., & Ramírez, M. (2007). Cambio de uso del suelo y degradación ambiental. *Ciencia*, 50–59.
- INEGI. (2009). *Guía para la interpretación de cartografía uso del suelo y vegetación, escala 1:250, 000*. México: Serie III de información de Uso del Suelo y Vegetación.
- INEGI. (2020). *Censo de Población y Vivienda*. México.
- INEGI. (2020). *Marco Geosestadístico Nacional*. México.
- Lugo Hubp, J. (2011). Diccionario geomorfológico. *Instituto de Geografía | Universidad Nacional Autónoma de México, Geografía para el siglo XXI (Obra general) Serie Textos universitarios*, 335.

- Mooser, F., Montiel, A., & Zúñiga, A. (1996). *Nuevo mapa geológico de las cuencas de México, Toluca y Puebla: estratigrafía, tectónica regional y aspectos geotérmicos*. México: Comisión Federal de Electricidad (CFE).
- OEA. Departamento de Desarrollo Regional y Medio Ambiente. Secretaría Ejecutiva para Asuntos Económicos y Sociales. (1993). Manual sobre el manejo de peligros naturales en la planificación para el desarrollo regional integrado. *USAID*. Obtenido de <http://www.oas.org/dsd/publications/unit/oea65s/oea65s.pdf>
- ONU. (2001). El ordenamiento territorial como opción de políticas urbanas y regionales en América Latina y el Caribe. *CEPAL – SERIE Medio ambiente y desarrollo*.
- Ordaz Hernández, A., Espinosa Rodríguez, L. M., Hernández Santana, J. R., & Expósito Castillo, J. L. (2018). Riesgo por procesos de vertientes y otros movimientos del terreno. En J.E. Baró Suárez, & F. Monroy Gaytán, *Enfrentando los riesgos socio-naturales*. CONACYT, Registro Nacional de Instituciones y Empresas Científicas y Tecnológicas.
- Reyes Enríquez, A., Valdéz Pérez, M. E., & Mireles Lezama, P. (2007). Geomorfología del Parque Nacional Nevado de Toluca. *Regionalidad y localidad en la Globalización, Varsovia, Edit*. Obtenido de <http://observatoriogeograficoamericalatina.org.mx/egal11/Procesosambientales/Geomorfologia/02.pdf>
- SEMARNAT. (2012). *Guía para la Elaboración de Planes de Acción Climática Municipal (PACMUN)*. México: ICLEI, Embajada Británica en México.
- Tarbutck, E. J., & Lutgens, F. K. (2005). *Ciencias de la Tierra. Una introducción a la Geología Física*. Madrid: Pearson Educación S.A.
- WRB. (2015). *Base referencial mundial del recurso suelo 2014, Actualización 2015. Sistema internacional de clasificación de suelos para la nomenclatura de suelos y la creación de leyendas de mapas de suelos. Informes sobre recursos mundiales de suelos 106*. Roma: FAO.
- Young Medina, M. A., & Yong Medina, J. E. (2011). *Ecología y medio ambiente*. Nueva Imagen S.A. de C.V.

Ariel Bernal Lima: is a geographer graduated from the Faculty of Geography at the Universidad Autónoma del Estado de México. Author of the Municipal Risk Atlas 2023 of Tenango del Valle. Environmental advisor to the Dirección de Medio Ambiente within COMPROBIDES in the municipality of Zinacantepec. Author of the first morphological inventory of species in the municipal nursery of Zinacantepec. Winner of the Municipal Youth Award "Jóvenes con talento," Zinacantepec 2022. Winner of the Presea Zinacantepec 2023 in the environmental field. Collaborator of PROMACC in Zinacantepec. Winner of the State Youth Award 2023 in the category corresponding to Environmental Protection. Among its most relevant actions are the verification of rock falls in the archaeological zone of Teotenango corresponding to the municipality of Tenango del Valle, workshops and talks for the care of the forest ecosystem in Zinacantepec, evaluations of the natural environment of Zinacantepec, expedition to the Ciénegas de Lerma to propose conservation alternatives, monitoring of greenhouse gases in Zinacantepec, preparation of the intermunicipal flood map of Calimaya, Chapultepec, Metepec, Mexicaltzingo, San Mateo Atenco and Tenango del Valle, preparation of a cartography of the natural environment of Zinacantepec and Tenango del Valle, and exploration of Área de Protección de Flora y Fauna Nevado de Toluca for the protection of the forest.