

Marginalization Within the Influence Areas of Biosphere Reserves in Mexico

Marginación en el área de influencia de las reservas de la biosfera en México

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ABSTRACT

This study analyzes the impact of marginalization on communities adjacent to biosphere reserves (BR), using the marginalization index as an analytical tool. Comparative maps of the BRs for the years 2000, 2010, and 2020 were developed. The findings show that by 2020, the number of inhabitants in these communities had decreased compared to 2000, and that the number of settlements increases with distance from the BR. A shift in marginalization levels is also observed: while a high degree prevailed in 2000, a medium level was recorded in 2020, despite a population decline of up to 28 percent. The analysis suggests that this decrease may be linked to regulatory restrictions inherent to protected natural areas, which may have influenced demographic dynamics within BR boundaries.

Keywords: 1. biosphere reserve, 2. marginalization, 3. public policy, 4. natural protected area, 5. Mexico.

RESUMEN

Esta investigación tiene como propósito analizar cómo incide la marginación en las comunidades adyacentes a las reservas de la biosfera (RB), utilizando el índice de marginación como herramienta analítica. Se elaboraron mapas comparativos de las RB correspondientes a los años 2000, 2010 y 2020. Se demuestra que en 2020 la población en estas localidades disminuyó respecto al año 2000 y que el número de localidades es mayor cuanto más alejadas se encuentran de la RB. Así mismo, se observa una transición en el nivel de marginación: en 2000 predominaba un grado alto, mientras que en 2020 se registró un nivel medio, aunque con una reducción poblacional de hasta 28 por ciento. El análisis sugiere que esta disminución puede estar relacionada con las restricciones normativas propias de las áreas naturales protegidas, lo que habría influido en la dinámica demográfica de las comunidades ubicadas dentro de los límites de las RB.

Palabras clave: 1. reservas de la biosfera, 2. marginación, 3. política pública, 4. área natural protegida, 5. México.

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INTRODUCTION

Mexico has 232 Protected Natural Areas (PNAs), which are designated by decree under six categories: national parks (79), biosphere reserves (48), flora and fauna protection areas (57), sanctuaries (28), natural resource protection areas (15), and natural monuments (5). These areas represent 10.9% of the country's terrestrial territory and 22% of its marine territory (Comisión Nacional de Áreas Naturales Protegidas [CONANP], 2022). They remain largely unaltered by human activity and require preservation and restoration; for this reason, they are governed by a defined regulatory framework that seeks to promote ecosystem conservation and protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente [LGEEPA], 1988).

According to the classification of Protected Natural Areas established in Mexican legislation, the biosphere reserve category is assigned to territorial units of biogeographic significance that represent one or more ecosystems in a conserved state or exhibiting minimal levels of human-induced alteration, and that require specific preservation and restoration measures. In this context, a biosphere reserve (BR) is a geographically defined area with ecological characteristics that sustain interactions among species representative of the country's biodiversity, including endemic species that are threatened or endangered. These areas commonly support species with high ecological specificity that rely on the particular conditions of the reserve for reproduction or development.

For these reasons, the conservation and protection of ecosystem services from the impacts of human activities are considered priorities, as is the promotion of remediation, recovery, and conservation of the natural environment. Maintaining intact trophic chains and preventing their disturbance or depletion is also essential. However, achieving these objectives presents challenges due to the restrictions and regulations that govern the direct or indirect use of these areas and their resources.

In the resolution of the United Nations Educational, Scientific and Cultural Organization (UNESCO, 1996), derived from the Seville Strategy, the concept of *biosphere reserves* is defined as one in which the conservation of biological diversity must be treated as a priority. This priority is expected to be integrated with the development of local communities by promoting the sustainable use of resources and the equitable distribution of the benefits derived from that use. Implementing this concept has proven challenging in the context of the social conditions present in human settlements, where inhabitants seek access to resources and ecosystem services that allow them to generate economic income and, at minimum, satisfy their basic needs.

Bezaury Creel and Gutiérrez Carbonell (2009) note that most Protected Natural Areas in Mexico include human settlements. This situation creates a dilemma for administrators and government authorities: on one hand, there is a demand for access to the environmental goods and services that a Protected Natural Area can provide; on the other hand, there is the imperative to conserve and protect the ecosystem. In this context, Vázquez León and Fermán Almada (2010) propose solutions such as promoting socioeconomic development within the institutional framework and designing environmental management policies that generate both direct and indirect benefits for users affected

by governmental restrictions and regulations. While these approaches are desirable, practical experience shows that tailored solutions are necessary for each region or community in which there is a demand for access to ecosystem services.

Furthermore, there is a notable contrast between the theoretical framework of what a biosphere reserve is intended to represent and the social and economic realities of the environment in which it is situated. This situation underscores the need to align the objectives of a biosphere reserve with the concept of territory, as well as with its social and economic dimensions, all grounded in an ecosystemic perspective. Several authors define this perspective as a set of socio-ecological systems in which social and economic dimensions are integrated with ecological dynamics (Binder et al., 2013; Challenger, 2016; Balvanera et al., 2017).

Declaring an area as ‘protected’ inherently creates potential conflicts between socioeconomic interests and ecocentric values, as traditional conservation approaches often assume that any economic activity threatens biodiversity and ecosystem functions. This situation generates a tension between two perspectives: conservation and economic development. Conservation is grounded in the intrinsic value of nature, whereas the economic perspective emphasizes its instrumental value (Kopnina et al., 2018). Conservationists and ecocentrists frequently advocate for the exclusion of human activities, which can lead to conflicts, social stress, and poverty, ultimately resulting in the illegal exploitation of natural resources. In this context, Brockington and Walkie (2015) highlight a series of contradictions between the idealized assumptions of conservation and the realities on the ground, which often produce injustice, exclusion, and poverty among indigenous and rural populations.

Anthropocentric thought, rooted in the ontological notion that humans possess a self-defined right to appropriate, dominate, and control nature as an instrumental resource, is often linked to Keynesian economic growth (Fuertes Grábalos et al., 2017). Over time, this perspective has evolved toward neoliberalism, which is founded on three main principles: the free market, unrestricted production, and the individual as both producer and consumer. Guided by the pursuit of maximum benefit, this framework has created a discourse of infinite and diverse supply to meet basic needs and generate economic profit. This conception of modern economic society overlooks the intrinsic value of natural resources and ecosystem services, whose depletion can result in both environmental and socioeconomic degradation, ultimately leading to marginalization.

Faced with the dilemma posed by the opposing principles of ecocentrism and anthropocentrism, the concept of sustainable development, as articulated in the Brundtland Report (United Nations, 1987), emphasizes both intergenerational and intragenerational justice by advocating the reduction of poverty and the equitable provision of environmental goods and services for future generations. Since its initial formulation, this principle has evolved toward practical applications for measurement and evaluation (Brenner, 2010). However, the diversity of proposed methodologies reflects the inherent plurality and complexity of such evaluations. As a result, the persistent challenge of excluding populations to conserve ecologically significant areas can deprive these

communities of the benefits derived from natural resources, generating social and economic stress and contributing to marginalization.

From a development perspective, marginalization is defined as the proportion of the population in a locality or community that lacks the factors necessary for progress, reflected in unequal access to basic goods and services. These factors are typically assessed across three dimensions: education, housing quality, and income generation (Cortés, 2002). In this context, the literature often refers to poverty as an indicator of the quality of life for populations living within a biosphere reserve. In contrast, this article treats marginalization as an analytical variable to examine the living conditions of communities located within such reserves.

Consequently, this article contributes to a critical line of research that warrants further exploration, particularly concerning the relationship between the conservation objectives of PNAs and the quality of life of local populations. It also underscores the importance of employing mixed-methods research that integrates qualitative and quantitative approaches, providing a foundation for the design of effective public policies that promote both conservation and the reduction of marginalization.

STATE OF THE ART

Since their establishment and recognition by UNESCO, biosphere reserves have been the focus of numerous studies, the majority of which are ecological in nature and emphasize conservation-related issues. In contrast, literature addressing the social dimensions of these areas is more limited, often adopting ethnographic, sociological, or cultural perspectives. A foundational work in this field is that of Oakerson (1986), which examines how environmental goods and services function as common-pool resources, shared and utilized by communities of producers or consumers who face the challenge of optimizing their use.

Similarly, Zhang et al. (2022) conducted a bibliometric analysis examining the relationship between PNAs and local communities. The study analyzed 5,584 articles published on the Web of Science platform between 2000 and 2021. The findings indicate that most publications originated from researchers in developed countries, primarily the United States, the United Kingdom, and Australia, although China also contributed a substantial number of studies on the topic. The authors report that the number of designated PNAs has increased, raising concerns about the changes and impacts these ecosystems have experienced due to human activities, while also noting a rise in related conflicts. The study further shows that, although community members are increasingly involved in the management and effective use of these areas, they are often excluded from governance and decision-making processes.

Among studies examining the socioeconomic and management dimensions of Protected Natural Areas, a recurring theme links the challenges of conservation as a public policy instrument with community demands for access to environmental resources and services. For instance, Joppa et al. (2009) analyzed population growth in 304 PNAs across 45 countries and found that, despite pressures arising from demand for access and use, there was no evidence of population increases

in surrounding communities. This reflects a tension between two outcomes: the anticipated benefits of conservation and the restrictions on access and resource exploitation. Such restrictions directly impact communities through geographic isolation and the economic marginalization of certain population sectors. Additionally, these factors influence decisions regarding whether inhabitants choose to remain in or migrate from these areas.

The study by Hummel et al. (2017) examines the differing perceptions of scientists and public administration officials regarding PNAs. The findings indicate that environmental scientists prioritize biotic and abiotic factors and the conservation of natural resources, whereas administrators focus on socioeconomic, cultural, and anthropogenic considerations. These differences can challenge efforts to balance environmental and social objectives, as management must account for both perspectives on the benefits associated with PNAs. Nonetheless, the effectiveness of protected area management depends on the specific region, the stakeholders involved, and the management model employed. In this context, Davies et al. (2018) note that PNAs are often established with ambitious objectives defined at the international level, which do not always align with local realities or the goals of the communities directly affected.

In the Mexican context, this pattern is consistent with studies on PNAs, as literature focusing on ecological aspects and conservation considerably outweighs research addressing social, economic, and institutional issues related to public policy and management (Lagunas-Vázquez et al., 2016; Wali et al., 2017; Gatica Colima, 2019; Reyna-Rojas et al., 2021). The work of Bezaury Creel and Gutiérrez Carbonell (2009) is particularly relevant to this study, as it focuses on PNAs in Mexico, their social functions, and their integration within communities. The authors examine these communities and connect levels of marginalization with productive activities and land ownership. They also note that, although PNAs are designated for multiple uses, the economic activities carried out within them are not necessarily oriented toward the sustainable use of resources.

This prompts reflection on the origins of the challenges frequently faced by Mexican PNAs, including poverty, resource overexploitation, conflicts over access, illegal activities, and unclear property rights. Among the most studied cases in Mexico are the Los Tuxtlas Biosphere Reserve in Veracruz and the Alto Golfo de California and Colorado River Delta Biosphere Reserve. Both reserves present a variety of conditions that illustrate the difficulty of balancing environmental and socioeconomic objectives. In this context, Beaucage (2010) highlights the administrative challenges and conflicts among users of the Los Tuxtlas Biosphere Reserve, which arise from differing objectives and affect local populations, often contributing to migration.

Regarding the Alto Golfo de California and Colorado River Delta Biosphere Reserve, several studies highlight conflicts between fishermen and conservationists, as governmental institutions have implemented policies that prohibit or severely restrict fishing, generating social and economic stress (Vázquez León, 2019). Similarly, Reyes Olivares et al. (2021) underscore the vulnerability created by human settlements within Mexican PNAs, where the demand for urban land for housing

affects the resilience of these areas and exposes deficiencies in the regulatory frameworks governing their management.

Similarly, García-Frapolli et al. (2009) examined two biosphere reserves and a flora and fauna protection area in the Yucatán Peninsula, Mexico. Their qualitative research indicates that inhabitants of these PNAs face restrictions on access to their lands, as well as limitations on the use and exploitation of environmental goods and services, which undermine both their economic development and cultural identity. The authors also note that residents feel excluded from decision-making processes and perceive a lack of engagement from the institutions responsible for conservation.

Auliz-Ortiz et al. (2023) investigate the relationship between conservation and poverty in PNAs in Mexico. The study employs the absolute marginalization index as an indicator of poverty and deforestation as a measure of the effectiveness of management plans. By comparing municipalities located inside and outside PNAs and examining the relationship between marginalization and deforestation, the authors argue that poverty arises, in part, from the restrictions imposed by the PNA management system. The study analyzes how management strategies interact with biophysical and socioeconomic factors to influence marginalization and forest loss. The authors report significant interactions between the restrictions established by different management plans and these biophysical and socioeconomic factors. In particular, they demonstrate that distance influences marginalization patterns, with PNAs located farther from urban centers experiencing higher levels of marginalization than those closer to cities.

Furthermore, with respect to the relationship between management plans and agricultural suitability, Auliz-Ortiz et al. (2023) note that, while marginalization levels in biosphere reserves remained relatively consistent across different agricultural contexts, other categories of PNAs display greater variability. This finding reflects the complex interplay between conservation strategies and local socioeconomic conditions.

Similarly, Aguilar-Cordero et al. (2024) report that the socioeconomic dynamics within the Cuxtal Ecological Reserve have served as a mechanism of capitalist development for urban planners, while simultaneously excluding and marginalizing local residents. They also identify factors that hinder community participation, including corruption, weak or absent oversight, and regulatory or censorial measures targeting community leaders or representatives. These conditions have contributed to migration from rural areas to urban centers in search of employment, resulting in the abandonment of productive lands and increased poverty.

Ruiz-Mallén et al. (2015) used observational methods and conducted interviews in rural communities within biosphere reserves in Mexico and Bolivia to examine community vulnerability and adaptation to regulatory frameworks. The authors conclude that conservation regulations create stress within these communities. They further observe that in Mexico, the imposed vertical, hierarchical management structure limits local adaptation, whereas in Bolivia, the absence of regulations and formal guidelines threatens livelihoods and subsistence.

These findings indicate that strict regulations designed to prioritize conservation restrict access to and use of natural resources, creating economic vulnerability within communities. Moreover, residents often experience feelings of helplessness and exclusion in the management of their resources, leading them to develop their own adaptation strategies to comply with management schemes and regulations, typically without support from the PNAs.

It is important to highlight the work of Ferraro et al. (2011), which investigates the relationship between poverty and the designation of PNAs through case studies in Costa Rica and Thailand. The authors examine the various impacts of policies implemented to prevent deforestation, including their economic effects on local populations. They conclude that PNAs do not inherently create poverty traps when protection is enforced and deforestation is avoided. However, they caution that this finding cannot be generalized, as external factors, such as proximity to urban centers, allow residents to pursue alternative economic activities.

In conclusion, while the literature on PNAs is extensive and diverse, studies specifically focused on biosphere reserves are less abundant, and even fewer examine social and economic impacts. The reviewed literature shows that ecological research predominates, whereas studies addressing socioeconomic challenges differ widely in their conceptual, methodological, and regulatory frameworks across regions and countries, making generalization difficult. Furthermore, most existing research tends to focus on regional and local issues.

RESEARCH OBJECTIVES

The marginalization index (MI) is a statistical measure that represents stratified levels of deprivation within communities. These levels are determined by geographic, economic, and social conditions that collectively reflect the population's deprivations and social exclusion (Consejo Nacional de Población [CONAPO], n.d.b). The objective of this article is to examine the incidence of marginalization within the territory of a biosphere reserve and its immediate area of influence, using the MI to assess social exclusion between communities located inside the PNA and those in its surrounding areas. The study focuses on the following central questions: 1) what is the incidence of marginalization in communities located within and adjacent to biosphere reserves in Mexico?; and 2) how has the degree of marginalization changed among populations residing in communities within and adjacent to biosphere reserves?

These questions are formulated to explain the relationship between the objectives outlined in the management plans of BRs and the marginalization of communities adjacent to or influenced by these PNAs, based on two conceptual lines: a) the notion of biosphere reserves as public policy instruments with defined objectives and constitutional foundations; and b) the definition of marginalization as an indicator of the performance of social and economic components within a biosphere reserve. To carry out the analytical and documentary work of this study, the grounded theory approach was implemented (Lúquez de Camacho & Fernández de Celayarán, 2016), which allows for the comparison of environmental, social, and economic indicators of communities influenced by the PNA with the objectives stated in its management plans.

BIOSPHERE RESERVES AS PUBLIC POLICY

PNAs are defined within a legal framework grounded in the Mexican Constitution, which, in Article 4, establishes that all individuals have the right to live in a healthy environment conducive to their development and well-being, and that national development must be sustainable (Constitución Política de los Estados Unidos Mexicanos [CPEUM], 1917). In this context, the promotion of social benefit and the sustainable use of natural resources is mandated, while preventing destruction and harm that could result from privatization or other practices detrimental to society.

Similarly, Articles 1 and 2 of the Ley General del Equilibrio Ecológico y la Protección al Ambiente² (LGEEPA, 1988) formalize the legal framework for the establishment and management of PNAs, specifying that they serve a purpose of public utility. Article 44 defines PNAs as areas of the national territory over which the nation exercises sovereignty and jurisdiction, and which are prioritized for the preservation and conservation of ecosystems that have not been significantly altered by human activity. In addition, the law establishes that inhabitants and landowners, holders or rights-bearers over land, water, and forest resources within PNAs, are subject to the decrees establishing these areas, as well as the regulations outlined in management and ecological planning programs.

In most PNAs in Mexico, communities exist whose populations rely on natural resources and ecosystem services, making residents subject to regulations governing their use and management. At the same time, the federal government is responsible for promoting community participation in programs aimed at the protection and preservation of ecosystems and biodiversity. PNAs classified as biosphere reserves are defined in Article 48 of the LGEEPA, while Articles 65 and 66 establish the mandatory nature of management plans and specify the content that these plans must include, respectively (LGEEPA, 1988).

BRs are designed and implemented with the objective of achieving maximum conservation, which has led to the establishment of a core zone and a buffer zone. The core zone is subject to the strictest restrictions on the use and exploitation of resources and ecosystem services, allowing only activities focused on conserving and preserving ecosystems and their components; these activities are regulated, and all extractive practices are prohibited. Population pressure is also intended to be minimized, requiring residents to pursue alternative economic activities outside the area. In the buffer zone, productive activities carried out by communities residing in the area at the time of designation are permitted, provided they are low-impact, impose minimal demands on the natural environment, and are compatible with the objectives of the reserve and sustainable utilization programs (LGEEPA, 1988, Article 47 BIS).

The concept of a biosphere reserve is grounded in the principles outlined in the Seville Strategy (UNESCO, 1996), which identifies three complementary functions for these areas: conserving genetic resources, ecosystems, and landscapes; promoting sustainable economic and human development; and supporting scientific and educational activities. These functions are closely

² General Law of Ecological Balance and Environmental Protection (unofficial translation).

linked to local initiatives that foster sustainable development. Moreover, the 21st-century framework proposed in the Seville Strategy underscores that biosphere reserves will play a decisive role in enabling the full and sustainable development of the populations living within or around these areas. It further anticipates that these reserves will respond to societal needs, thereby charting a pathway toward a sustainable future. This perspective aligns with the provisions of the LGEEPA and the Programa Nacional de Áreas Naturales Protegidas³ (2020–2024) (CONANP, 2020), which asserts that the preservation and restoration of the natural environment serve as catalysts for development and national security. Achieving these goals requires the integration of communities and their activities, thereby supporting indigenous identity, food security, and sustainable development.

Within the legal framework governing BRs, the State is defined as the authority responsible for managing ecosystem resources. Through regulatory instruments, it controls access to and economic activities within PNAs by users and community inhabitants, aiming to prevent threats or risks to ecosystems. The purpose of this regulatory intervention is to address situations perceived as socially problematic or risky and, based on these perceptions, to guide the implementation of public policies. This approach aligns with the concept of public policy proposed by Subirats et al. (2008), which emphasizes the interaction of public and private actors within an institutional framework to address collective problems. However, Ávila-López and Pinkus-Rendón (2018) observe that the solutions provided by biosphere reserves are often partial, as the restrictions imposed can adversely affect surrounding communities. In other words, from a conservationist perspective, management is achieved and resource use is regulated, but the social and economic components of sustainable development outlined in the legal and institutional framework may be compromised.

In this context, it is important to highlight Article 44 of the LGEEPA (1988), which establishes that inhabitants of PNAs must comply with the legislation set forth in the management program, as well as regulations affecting properties, regardless of the ownership regime. This provision is significant because it clarifies the legal responsibilities that residents and users within a PNA are required to assume. Additionally, it is important to consider that many communities were already established in these areas prior to their designation as protected.

For instance, Bezaury Creel and Gutiérrez Carbonell (2009) report that in 2005, PNAs in Mexico were home to 3 448 470 inhabitants across 900 areas, representing 3.34% of the country's total population. Of these residents, 93% lived under very high, high, or medium levels of marginalization, reflecting considerable pressure on natural resources and ecosystem services. A significant portion of PNA territory is privately owned (56%), with the remainder held under social property regimes, such as ejidos or public ownership. Furthermore, the government does not systematically consider compensation as a tool for conservation and preservation when establishing PNAs, although some support and compensation programs exist for communities, including initiatives that permit the purchase of resource exploitation rights.

³ National Program of Protected Natural Areas (unofficial translation).

PROBLEM STATEMENT

The motivation for this research stems from the observation that biosphere reserves in Mexico operate under paradoxical mandates. On one hand, their legal foundations and the objectives underlying their designation suggest that conservation is achieved through the exclusion of human activities. On the other hand, it is argued that the participation and inclusion of communities influenced by these reserves can foster local and regional development while also safeguarding the well-being of future generations by ensuring the continued availability of ecosystem goods and services.

This article addresses a general problem observed in Mexican biosphere reserves: the conflict between conservation as a public policy and the demand for access to goods and services that support social and economic well-being. This issue involves diverse and context-specific factors, making generalization difficult, as outcomes depend on community social structures, ecosystem fragility, relationships among inhabitants, and the institutions responsible for managing the reserves. Government intervention in a PNA is justified by recognizing its unique ecological characteristics and identifying human activities that may alter or threaten ecological processes and balance, thereby compromising sustainable development and affecting future generations. As a result, official intervention often relies on the establishment of isolated areas, which tends to overlook local social and economic dynamics.

A biosphere reserve as a public policy is managed through the identification of an ecosystem problem that threatens social functionality (Subirats et al., 2008). Within this framework, regulatory instruments (decrees and management plans) evaluation tools, and the designated agents responsible for implementing these controls are defined to minimize or eliminate the social risks associated with the identified problem. This political approach to protection and conservation in Mexican biosphere reserves often results in the passive exclusion of communities (García-Frapolli, 2015) and the traditional activities they have historically practiced, producing both social and economic impacts (Brosius, 2003).

Consequently, legislation is enacted to restrict or limit community access to environmental goods and services, constraining economic and subsistence activities. Similarly, community participation and integration in the management of PNAs are minimal or absent, despite the potential contributions of local knowledge regarding natural processes, resource use, and capacities within the area (Wali et al., 2017; Muñoz Mendoza et al., 2022). This situation complicates the management of biosphere reserves, as it leads to the economic deterioration of residents due to exclusion, regulations, and prohibitions that limit their ability to utilize environmental resources and services, thereby exacerbating marginalization (Brockington & Walkie, 2015).

METHOD

The research is designed using a grounded theory methodological approach, which allows for the integration of qualitative and quantitative information. The study examines reality through documents, data, reports, and interviews (Strauss & Corbin, 2002), as well as regulatory information, mathematical indicators, and statistical analysis. Drawing on a theoretical framework (Vivar et al.,

2010), the study addresses the context of the research object, structured around three interconnected concepts analyzed using specific techniques: the conceptual framework of a PNA, specifically a biosphere reserve, the conceptual framework of marginalization and its national-level measurement, and the conceptual framework of the management and administration of a biosphere reserve.

These reference frameworks are compared with the objectives and regulatory provisions that govern the management of biosphere reserves. The theoretical-conceptual framework facilitates the delineation of study objectives and the definition of comparative data analysis procedures. Throughout the research, theory is consistently used to contrast field data with existing information. Through this process of constant comparison, the characteristics defined in the theoretical frameworks are validated against observed reality, including attributes and features identified in the field and within the compiled data (Bonilla-García & López-Suárez, 2016).

The methodology of this study was structured around two main axes. The first axis conceptually defined the category of biosphere reserve as a PNA, with the objective of delineating the mandates of management plans and identifying regulatory elements within the legal and institutional framework, as well as the defining components of biosphere reserves established by institutional foundations, predetermined objectives, and regulations (LGEEPA, 1988). The second axis involved the geographic identification of communities located within the biosphere reserve and in adjacent areas. Each reserve was digitized, and dynamic maps were created using ArcGIS® based on the distribution and location of PNAs according to CONANP. This approach produced georeferenced maps to delineate equidistant perimeters around each reserve's boundaries, overlaid maps for each year of analysis, and incorporated census data and management characteristics for each reserve, enabling the observation and identification of changes over the study period.

To analyze marginalization, the study examined populations residing in communities within and adjacent to the biosphere reserves. Using CONANP cartography, maps were created that integrated the biosphere reserves and located settlements with more than nine inhabitants. Perimeters were established, and communities were identified and classified as being either within the reserve or at distances of 5, 10, and 15 km from the designated PNA boundaries.

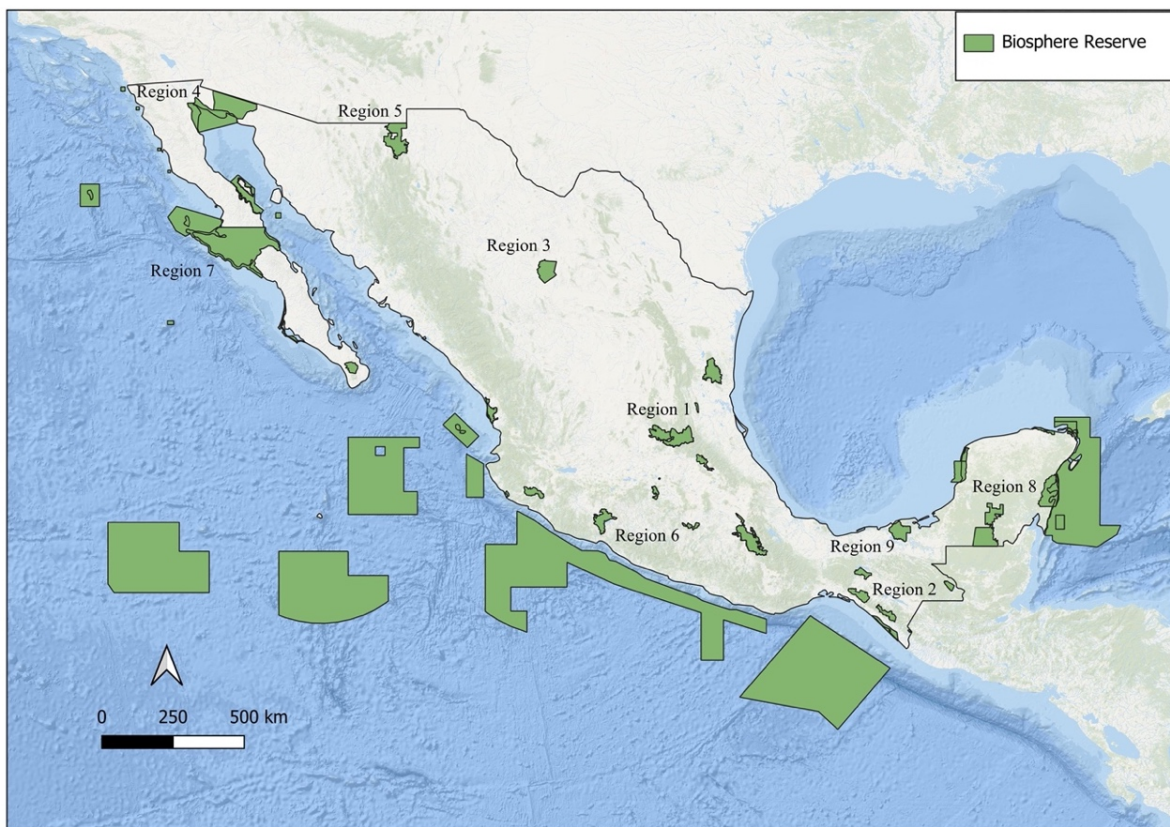
These perimeter distances were selected to capture the direct influence of biosphere reserves on surrounding communities, as population distribution patterns become more pronounced with increasing distance. For instance, notable differences exist between reserves in northern Mexico and those in the central and southeastern regions regarding the presence and distribution of communities within these perimeters. Northern reserves generally have fewer inhabitants in adjacent communities, whereas southern reserves exhibit a much higher density of local populations. Consequently, expanding the perimeter distance could exclude some PNAs from the study due to the limited or nonexistent presence of communities, as is the case with the Janos Biosphere Reserve and the Alto Golfo de California and Colorado River Delta Biosphere Reserve.

Additionally, government statistical databases were reviewed to obtain marginalization indicators from 1995 to 2020, evaluate regional development levels, and analyze the socioeconomic characteristics of the population. Key sources included the Instituto Nacional de Estadística y

Geografía⁴ (INEGI, 2020b), the Consejo Nacional de Población⁵ (CONAPO, n.d.a), the Consejo Nacional de Evaluación de la Política de Desarrollo Social⁶ (CONEVAL), the Comisión Nacional de Áreas Protegidas⁷ (CONANP), and the Sistema Nacional de Información Estadística y Geográfica⁸ (SNIEG, n.d.),⁹ among others.

In Mexico, 46 areas are designated as biosphere reserves, which are classified into nine regions (Map 1). From these, nine representative reserves—one from each region—were selected based on attributes such as the number of communities within and surrounding the defined perimeters, total population, and degree of marginalization (Table 1).

Map 1. Location of Regions and Biosphere Reserves in Mexico



Source: Own elaboration based on information from INEGI (n.d.) and CONANP (2022).

⁴ National Institute of Statistics and Geography (unofficial translation).

⁵ National Population Council (unofficial translation).

⁶ National Council for the Evaluation of Social Development Policy (unofficial translation).

⁷ National Commission of Protected Natural Areas (unofficial translation).

⁸ National System of Statistical and Geographic Information (unofficial translation).

⁹ The latter was obtained through the *Catálogo Nacional de Indicadores* (National Catalog of Indicators).

Table 1. Selected Regions and Biosphere Reserves

Region	Biosphere reserve
1. Central Region and Neovolcanic Axis	Mariposa Monarca Sierra de Huautla Sierra Gorda Sierra Gorda de Guanajuato Barranca de Metztlán Tehuacán-Cuicatlán
2. Southern Border-Isthmus and Southern Pacific	El Triunfo La Encrucijada La Sepultura Volcán Tacaná Montes Azules El Ocote Lacan-Tun
3. Northeast Region and Sierra Madre Oriental	Mapimi Sierra del Abra Tanchipa
4. Northwest Region and Alto Golfo de California	Alto Golfo de California y Delta del Río Colorado El Pinacate y Gran Desierto de Altar Isla San Pedro Mártir
5. Northern Region and Sierra Madre Occidental	Janos Michilía
6. Western Region and Central Pacific	Chamela-Cuixmala Marismas Nacionales Nayarit Sierra de Manantlán Zicuirán-Infiernillo Islas Marías
7. Baja California Peninsula and Northern Pacific	El Vizcaíno Isla Guadalupe Islas del Pacífico de la Península de Baja California Reserva de la Biosfera Pacífico Mexicano Profundo Sierra La Laguna Complejo Lagunar Ojo de Liebre Zona Marina Bahía de los Ángeles, Canales de Ballenas y de Salsipuedes
8. Yucatán Peninsula and Mexican Caribbean	Los Petenes Ría Celestún Tiburón Ballena Banco Chinchorro Calakmul

(continues)

Region	Biosphere reserve
<i>(continuation)</i>	Caribe Mexicano
	Ría Lagartos
	Sian Ka'an
9. Coastal Plain and Gulf of Mexico	Los Tuxtlas
	Sierra de Tamaulipas
	Pantanos de Centla

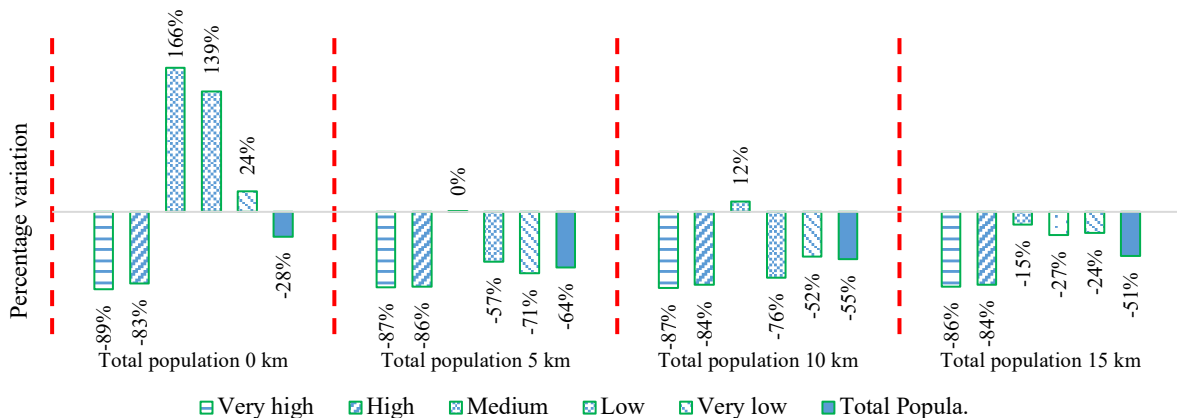
Source: Own elaboration based on information from INEGI (n.d.) and CONANP (2022).

RESULTS

The data obtained from the consulted databases generally indicate that both population and the number of communities increase with greater distance from the PNA; in other words, the farther from the biosphere reserve, the more inhabitants and communities are present. In 2000, the total population residing within the area designated as a biosphere reserve was 404 743 individuals across 2 108 communities, whereas by 2020, this had decreased to 289 535 inhabitants in 1 766 communities. Overall, this shows that there is a declining trend in population and, therefore, a decrease in the number of communities within PNAs.

In absolute terms, the population of these communities in 2000 exhibited predominantly high and very high levels of marginalization. By 2020, this condition had shifted, with the majority of the population experiencing medium and low levels of marginalization. Notably, in 2020, the population represented 71.5% of the total inhabitants recorded in 2000, indicating a 28.5% decline over two decades. When analyzing changes in the classification of populations residing within the biosphere reserves, it is evident that between 2000 and 2020, the proportions of very high and high marginalization decreased to 89 and 83%, respectively, while medium and low marginalization levels increased significantly to 166 and 139%, respectively (Graph 1).

Graph 1. Percentage Variation of the Population by Level of Marginalization, 2000–2020



Source: Own elaboration based on population census data from INEGI (2000, 2003, 2010, 2020a, 2020b).

The information obtained from INEGI databases for the years 2000, 2010, 2015, and 2020 shows that, overall, the total number of inhabitants in areas within and surrounding the biosphere reserves has decreased. The population of communities located within a 5-km perimeter of the BRs declined by up to 64% between 2000 and 2020, resulting in greater variation in marginalization levels. Specifically, the population classified with very high marginalization decreased by up to 87%, while the population with medium marginalization increased. This pattern is consistently observed across communities within perimeters of up to 15 kilometers surrounding the BRs. Overall, although the population in 2020 was lower than in 2000, the majority shifted to a medium level of marginalization.

An analysis of the population residing within the protected areas of biosphere reserves during 2000, 2010, and 2020 revealed that six reserves have the highest population levels: Sierra Gorda, El Vizcaíno, Tehuacán-Cuicatlán, Barranca de Metztitlán, Pantanos de Centla, and Mariposa Monarca. The most populated reserve is the Sierra Gorda Biosphere Reserve, with an average of 89 590 inhabitants distributed across 535 localities within the protected area (Table 2).

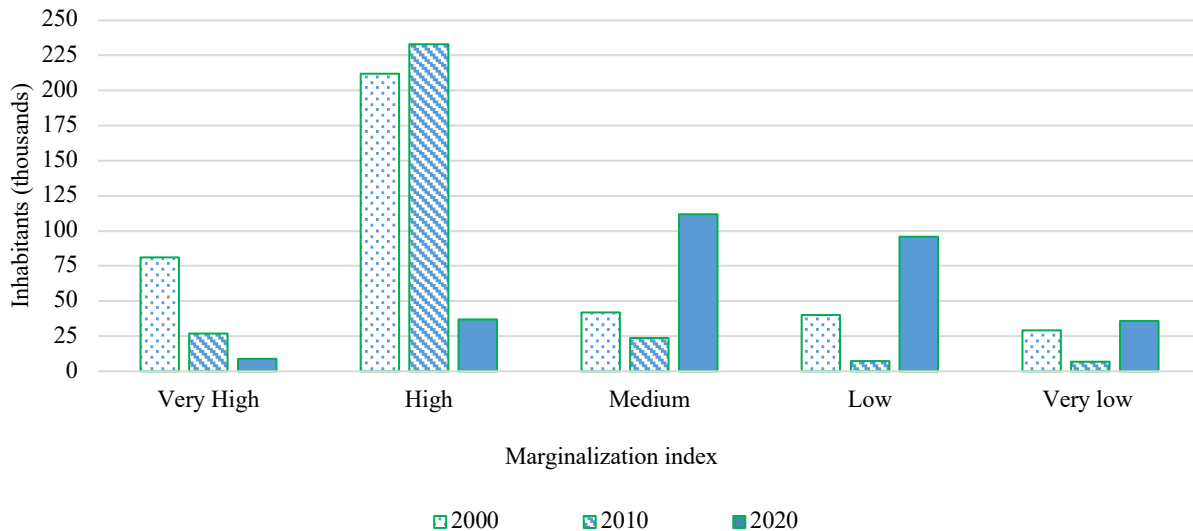
Table 2. Population of Localities Within the Most Populated Biosphere Reserves, 2000–2020

Biosphere Reserve	Population 2000	Biosphere Reserve	Population 2010	Biosphere Reserve	Population 2020
Sierra Gorda	94 013	Sierra Gorda	98 347	Sierra Gorda	76 739
El Vizcaíno	38 014	El Vizcaíno	50 780	Tehuacán-Cuicatlán	27 502
Tehuacán-Cuicatlán	35 990	Tehuacán-Cuicatlán	36 127	Pantanos de Centla	22 972
Barranca de Metztitlán	25 842	Mariposa Monarca	27 324	Mariposa Monarca	20 423
Mariposa Monarca	23 684	Barranca de Metztitlán	26 458	Barranca de Metztitlán	20 475

Source: Own elaboration based on population census data (INEGI, 2020b).

Regarding the level of marginalization in communities within the BRs, the data indicate that in 2000 and 2010, the population primarily experienced very high and high levels of marginalization, respectively. By 2020, this shifted predominantly to a medium level. This change may be partly associated with the decline in the resident population and the potential migration of individuals to other areas in search of employment or alternative productive activities outside the biosphere reserves (Graph 2).

Graph 2. Resident Population and Level of Marginalization in Communities Within Biosphere Reserve Areas, 2000–2020



Source: Own elaboration based on population census data from INEGI (2000, 2010, 2020a, 2020b).

When comparing population distribution by marginalization level and proximity to the biosphere reserves during 2000, 2010, and 2020, it is evident that the distribution pattern changes both with distance from the reserve and over time (Graph 3). In 2000, the majority of the population residing within the reserve experienced a high level of marginalization (52%), with 72% of the population collectively falling within the very high and high categories. For communities located at 5, 10, and 15 km from the BR, the resident population exhibited a distribution concentrated at the extremes of marginalization. For example, in communities 5 km from the BR, 39% of the population fell within the high categories (very high and high), while 50% were in the low and very low categories (31 and 19%, respectively). This pattern was similar for localities 10 and 15 km from the reserve, with a notable finding that at 15 km, 51% of the population experienced high marginalization, whereas 37% fell into the low category. These data indicate that in 2000, a clear pattern of inequality prevailed.

Graph 3. Population Distribution According to Degree of Marginalization in Biosphere Reserves and Adjacent Areas, 2000, 2010, 2020



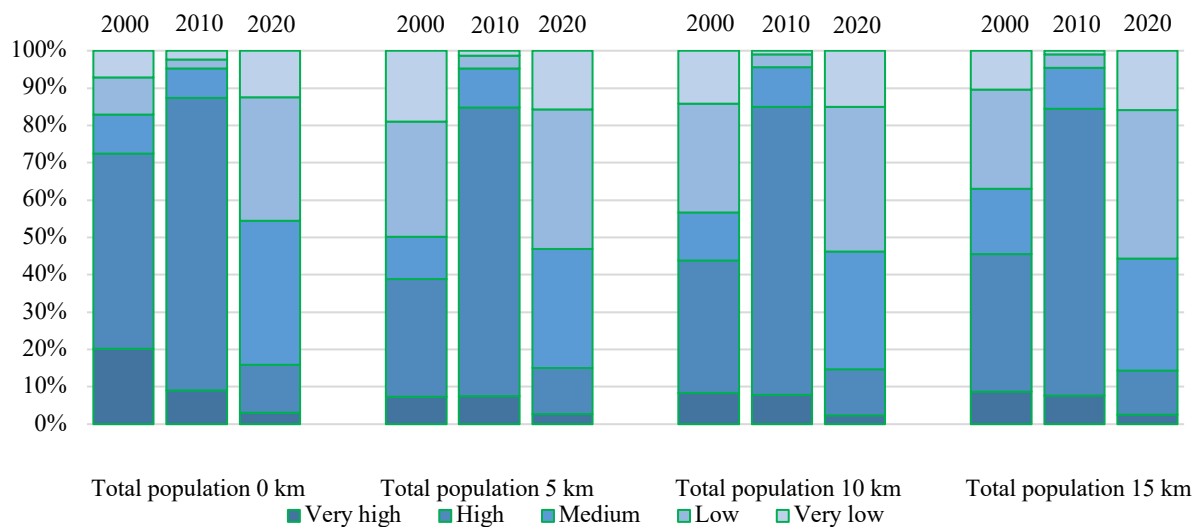
Source: Own elaboration based on population census data from INEGI (2000, 2003, 2010, 2020a, 2020b).

Overall, Graph 3 shows that, during the 2000–2010 period, the population distribution in localities located within the reserve and in those farther away (up to 15 km) was predominantly characterized by high levels of marginalization. This condition changed over time. By 2020, the

population had decreased, and the distribution across marginalization levels had shifted. Most of the population residing within the BR was classified in the medium (39%) and low (33%) marginalization categories, meaning that 72% fell within the medium and low levels combined. A similar distribution was observed in the localities located outside the protected area.

Graph 4 illustrates how the distribution of the population by marginalization level has changed over time. In 2000, most of the population (72%) residing within the protected area was characterized by very high and high levels of marginalization, in contrast to the localities outside the protected area, where marginalization levels were more diverse—ranging from high to medium and low. The graph also shows that by 2020, the population was concentrated primarily in intermediate marginalization levels (medium and low). In both the localities located within the biosphere reserve (0 km) and those farther away, the majority of the population (70%) fell within the medium and low marginalization categories.

Graph 4. Percentage of the Population by Level of Marginalization and Distance from the Biosphere Reserve



Source: Own elaboration based on population census data from INEGI (2000, 2003, 2010, 2020a, 2020b).

DISCUSSION

Based on the results obtained, it is possible to explain the incidence of marginalization among the communities located within and adjacent to the BRs, thereby addressing the first research question. The findings reveal an overall decrease in the intensity of marginalization (Graph 2). This trend can be explained, in part, by the decline in population, as residents tend to migrate outside the reserves in search of employment and income-generating activities (Graph 3), which aligns with the observations of Bezaury Creel and Gutiérrez Carbonell (2009). The evidence shows that the population living in communities within the biosphere reserves decreased over the study period.

Additionally, the results indicate marked differences between the populations residing within the reserves and those in adjacent communities, which is consistent with the literature.

In general, it is evident that the population residing in communities within the biosphere reserves has decreased. However, the causes underlying the variation in marginalization levels are not straightforward to identify, as they are influenced by factors that are inherently difficult to disentangle, such as changes in the structure of the variables used by INEGI and CONEVAL (Peláez Herreros, 2023). Furthermore, BRs in the country are not contemporaneous: some were created only recently, while others were established 30 or 40 years ago. This temporal heterogeneity also complicates efforts to isolate the factors driving changes in marginalization.

Regarding the second central question posed in this article, it is important to consider that biosphere reserves function as public policies whose regulations restrict access to and use of natural resources for residents of communities located within and adjacent to these areas. Consequently, these inhabitants often seek employment elsewhere or migrate to urban centers (Aguilar-Cordero et al., 2024). This pattern may represent an adaptation mechanism developed over time by residents in response to prevailing regulations, influencing the demographic configuration of the territory, as reflected in the variations recorded in recent years (Table 1).

Another factor to consider is that INEGI and CONEVAL have modified the definition of “community” for inclusion in census statistics, based on population size. In this context, it is important to identify the categories in which localities are classified within the catalogs published by INEGI (n.d.). For instance, some localities previously lacked geostatistical records or were removed from them; others appear or disappear in different catalogs due to relocation, corrections, or boundary adjustments; and some localities change category as a result of population increases or decreases.

According to Peláez Herreros (2017), CONAPO introduced and modified the estimates for 2010, 2015, and 2020 based on the transformation of the ordinal marginalization index (MI) into a cardinal measure, allowing marginalization to be compared in percentage points over time. Therefore, the author notes that the mathematical and statistical nature of the variables that make up the marginalization index has been modified, particularly those that have been restructured over time: “Percentage of the population aged 15 and over without basic education” (previously called “Population aged 15 or older without completed primary education”), “Percentage of occupants in private dwellings without drainage or sanitary facilities,” and “Dwellings with some level of overcrowding.” In this regard, modifications to the variables estimating overcrowding and dwellings without drainage or sanitary facilities generate changes in the calculated MI (Peláez Herreros, 2023).

It is worth noting that these variables are particularly significant when quantified in communities with small populations, as each absolute value strongly influences the relative measures. Marginalization levels are expected to decrease for two main reasons: first, populations located farther from the biosphere reserve tend to be larger, which directly affects the variable “Population in localities with fewer than 5 000 inhabitants”; and second, the results indicate that

population size increases with greater distance from the reserve area (Graph 3) (Auliz-Ortiz et al., 2023).

The second factor contributing to the variation in marginalization levels is the lack of infrastructure in most biosphere reserves, except for those located in or near urban areas. For instance, limited access to schools or educational centers is a key infrastructural factor influencing this variation, as reflected in the variables “Number of illiterate individuals aged 15 and over” and “Population aged 15 and over without completed primary education.” Additionally, regarding housing conditions, communities with small populations often lack adequate infrastructure to provide finished floors or sanitary drainage in homes. This deficiency affects the marginalization indicator through the components “Occupants in dwellings with dirt floors” and “Occupants in dwellings without drainage or sanitary facilities.”

Marginalization levels decreased over the study period. In the initial year, the population residing in communities within the reserves was classified as experiencing very high and high marginalization, whereas by 2020, these levels had shifted to intermediate categories. The data and analysis suggest that the population decline within these communities can be partially attributed to the regulations and restrictions imposed in the BRs, which limit access to productive activities and, consequently, income generation, thereby affecting community development. In response, residents either adapt to these conditions or migrate to urban areas in search of employment.

This article is significant because it examines two interrelated aspects: the marginalization of populations in communities influenced by BRs, and the reserves themselves as public policies that impose restrictive norms and regulations through their management plans. Furthermore, the study introduces an avenue for analyzing the effectiveness of BRs in relation to constitutional principles and the concept of sustainable development in Mexico. Nevertheless, the research has limitations, including its inability to fully explain the spatial distribution of marginalization. This limitation points to new questions for future studies, which could explore marginalization patterns while accounting for spatial correlations among communities with similar marginalization indices and the regulatory framework of the reserves.

A pertinent critique of this study concerns the generalization made in analyzing the BRs, their adjacent communities, and the corresponding levels of marginalization. Marginalization, as a descriptive indicator of community deprivation and social exclusion, is insufficient on its own to support broad generalizations. Communities within the studied perimeters exist under regulatory and normative frameworks specific to each reserve, as established by their respective management plans and the LGEEPA. Additionally, the reserves were created in different years, which may contribute to variations in marginalization depending on the age and maturity of each biosphere reserve.

Another element relevant to the discussion is the presence of various social programs targeting specific sectors within these communities, such as producers, fishers, loggers, miners, and collectors. In other words, there are no uniform programs aimed at entire communities; rather, interventions are directed at populations affected by the management and governance policies of a BR. In Mexico, over different periods, social programs have been implemented to directly or indirectly replace or

supplement income. These include the Programa de Conservación para el Desarrollo Sostenible¹⁰ (PROCOCODES), the Programa de Conservación de Especies en Riesgo¹¹ (PROCER) (CONANP, 2024), the Programa Especial Concurrente para el Desarrollo Rural Sustentable¹² (PEC), the Programa de Desarrollo Regional Sustentable¹³ (PRODERS), and the Programas de Reconversión Productiva,¹⁴ among others. Such initiatives influence household income and, consequently, impact the marginalization indicator “Employed population with income of up to two minimum wages.”

Therefore, caution is required when generalizing results regarding marginalization levels in communities adjacent to biosphere reserves, as these communities do not exist in homogeneous contexts. This observation underscores the importance of considering local and temporal circumstances, given that the structures of marginalization are dynamic and that their measurement reflects a context adapted to the social needs and deprivations present at each point in time (Peláez Herreros, 2023).

CONCLUSIONS

This article examines the distance between a locality and the biosphere reserve as a factor influencing the interaction between community residents and reserve management. It also considers environmental management policies that affect residents’ choices regarding productive activities, thereby impacting income generation and overall well-being. Moreover, the formal definition of marginalization through a multifactorial index allows for the identification of population deficiencies. Its significance lies in representing the development of social and economic capacities in a region, based on access to education, housing, and essential goods and services, as well as income derived from labor (CONAPO, 2020). While this marginalization index is not exclusively linked to restrictions limiting access to the reserves, it can be associated with the loss of capacities and the diminished right to access natural resources necessary to generate income and address these deficiencies.

Marginalization is understood as the manifestation of deficiencies within a community’s population, reflecting both structural and situational factors. Structural factors pertain to the effects of economic and political management and administration at national and regional levels, over which the community and its members have little or no influence. In contrast, situational factors recognize that more effective management and administrative options may exist at the regional, community, or individual level.

The primary purpose of a BR in Mexico is conservation; however, the legal framework also mandates the inclusion of resident communities in management plans to promote sustainable

¹⁰ Conservation for Sustainable Development Program (unofficial translation).

¹¹ Endangered Species Conservation Program (unofficial translation).

¹² Special Concurrent Program for Sustainable Rural Development (unofficial translation).

¹³ Sustainable Regional Development Program (unofficial translation).

¹⁴ Productive Reconversion Programs (unofficial translation).

development. In practice, this inclusion is not fully realized, as marginalization persists at medium levels and the population within these communities has declined. This indicates that, while conservation objectives are being advanced, local populations remain largely excluded, and their socioeconomic and developmental activities are restricted.

It is important to emphasize that marginalization stems from a historical pattern in which effective public policies to promote development have not been implemented, alongside the existing productive structures in different regions of the country. Moreover, certain social groups have been systematically excluded through institutional provisions and social programs intended to replace income traditionally generated by established production activities.

The marginalization index has been employed for several reasons. One is the high level of disaggregation provided by official Mexican statistics, which describe the socioeconomic dynamics of the population from the perspective of deprivation and segregation. The index comprises social and economic factors that reflect circumstances arising from either the implementation or absence of public policies. Additionally, it can be related to the natural environment through residents' capacity to engage in self-employment as producers. Marginalization also reflects the lack or exclusion of conditions corresponding to human rights, such as access to education, adequate housing, health, and income, as well as the right to enjoy and live in a healthy environment. Thus, the paradox highlighted in this study is that, on one hand, there is a clear need to create favorable social and economic conditions, while on the other, communities are deprived of the right to use and exploit natural resources to generate income.

Translation: Erika Morales.

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