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Compliance with MAB-UNESCO Functions and Management Effectiveness Evaluation between 2017 and 2024: Case Study of the El Cielo Biosphere Reserve, Mexico's Only State-Run Reserve Belonging to MAB-UNESCO

Frida Carmina Caballero-Rico [1,*], Ramón Ventura Roque-Hernández [2], Carlos Barriga-Vallejo [3,4,*], Rubén A. Valero-Castillo [5,6], Ricardo Rozzi [7,8,9] and Arturo Mora-Olivo [3,10]

1 Faculty of Commerce and Administration-Victoria, Autonomous University of Tamaulipas, Victoria City 87149, Mexico
2 Faculty of Commerce, Administration and Social Sciences, Autonomous University of Tamaulipas, Nuevo Laredo 88275, Mexico; rvhernandez@uat.edu.mx
3 Institute of Applied Ecology, Autonomous University of Tamaulipas, Victoria City 87019, Mexico; amorao@docentes.uat.edu.mx
4 Tamaulipas Ecoregions and Wetlands Program, Pronatura Noreste, Monterrey 64710, Mexico
5 Economic-Administrative Area, Tecnológico Nacional de Mexico Campus Ciudad Victoria, Victoria City 87010, Mexico; ruben.valero@tamaulipas.gob.mx
6 Tamaulipas Parks and Biodiversity Commission, Tamaulipas State Government, Victoria City 87083, Mexico
7 Cape Horn International Center (CHIC), Puerto Williams 6350000, Chile; ricardo.rozzi@unt.edu
8 Parque Etnobotánico Omora, Universidad de Magallanes, Puerto Williams 6350000, Chile
9 Sub-Antarctic Biocultural Conservation Program, Department of Philosophy and Religion and Department of Biological Sciences, University of North Texas, Denton, TX 76205, USA
10 Faculty of Engineering and Science, University of Tamaulipas, Victoria City 87149, Mexico
* Correspondence: fcaballer@uat.edu.mx (F.C.C.-R.); cbarriga@pronaturane.org (C.B.-V.)

Abstract: UNESCO's MAB Programme promotes a people-centered conservation strategy to strengthen the sustainability of social and ecological systems. However, there exist knowledge gaps regarding its implementation in specific contexts. For this study, a mixed-methods sequential exploratory design was employed. In the first phase, an initial content analysis of the management program of the El Cielo Biosphere Reserve (CBR) and the functions of the statutory framework of UNESCO's MAB program was conducted. This analysis, which was human-driven but facilitated by artificial intelligence tools, underwent rigorous triangulation and expert validation to strengthen the reliability and robustness of the findings. Subsequently, the Management Effectiveness Tracking Tool (METT3) was issued to researchers, community members, civil servants, and former civil servants related to the management of the CBR. The 2024 results (n = 15) were contrasted with those obtained in 2017 (n = 15) using a quantitative approach consisting of descriptive, non-parametric, and Bayesian statistical techniques. We identified some problems in the implementation of the MAB-UNESCO Programme in the CBR, mainly due to the outdated management program and lack of effective governance, as well as the lack of understanding of the implications of being a MAB-UNESCO biosphere reserve. A numerical trend of deterioration in the effectiveness of the CBR's management was detected, with overall ratings of 44.78% and 29.62% in 2017 and 2024, respectively. This was associated with a lack of regulation, weak coordination among key actors, and a progressive reduction in funding. The findings of this study are useful to guide the transition of the CBR towards a conservation model that responds to current problems and contributes to the advancement of knowledge on the implementation of the MAB Programme in specific contexts.

Keywords: Man and the Biosphere Programme; management program; governance; biodiversity conservation; collaboration; artificial intelligence

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1. Introduction

The Man and the Biosphere (MAB) program of the United Nations Educational, Scientific and Cultural Organization (UNESCO) aims to foster the harmonious relationship between people and their environments, promoting practices that enable sustainable development in biosphere reserves (BRs) [1,2]. These areas, designated as living laboratories, are essential for researching and evaluating the implementation of sustainable development practices through the integration of natural and social studies that improve the well-being of people and natural ecosystems [3].

Although BRs are implemented based on general guidelines, it is crucial that they adapt their implementation to specific local conditions. Such an approach aligns with a key policy of UNESCO's MAB Programme, which includes the *Statutory Framework and Technical Guidelines for Biosphere Reserves* [4]. These documents recognize that prescriptive implementation guidelines would not be effective without this local adaptation [5,6].

The 1995 *Statutory Framework of the World Network of Biosphere Reserves* [5] describes the functions that BRs should fulfill as follows: *biodiversity conservation, sustainable development, logistical support for research and capacity building*, and *climate change mitigation.*

In addition to making sustainability a key function of BRs, the framework defines the territorial zoning structure in three zones—namely, core, buffer, and influence zones—as well as describing the obligation for periodic review (Art. 9). In these reserves, biodiversity conservation and human development are equally important, and they have been conceptualized as spaces where human–environment relationships are understood through collaboration and knowledge exchange among the different stakeholders involved [7,8]. To fulfill the biodiversity and sustainable development objectives, BRs have shifted from studies of natural resources to studies of social dynamics and the systemic analysis of regions [2].

With more than 700 reserves in 129 countries, the MAB Programme focuses its efforts on identifying and assessing changes in the biosphere, studying the relationships between ecosystems and socio-economic processes, ensuring basic human well-being and a livable environment, and promoting the exchange and transfer of knowledge to achieve a significant impact on global conservation. The program is facing great challenges due to the variability in political and financial commitments to reserves, and it has been found that the lack of resources available to BRs is a major factor leading to their failure, as well as a lack of process continuity [9]. Resource constraints have been shown to be significant setbacks for MAB implementation in developing countries [7,10], and biosphere reserves have been found to remain under-utilized, in terms of their contributions to the theory and practice of sustainability science. Thus, more interdisciplinary research and monitoring is needed to generate conceptual and practical knowledge regarding the relationships between people and the environment, as well as the consequences of biodiversity conservation [2].

The current MAB Strategy 2015–2025 and Lima Action Plan (LAP) 2016–2025 [1] call for participatory planning around individual BR implementations that is effective and equitable, with the support of local and national governments and the private sector [4]. However, there is a knowledge gap in how these principles are transposed in specific contexts, generating a need for location-specific studies [7].

The MAB-UNESCO model is conceptually appealing; however, the implementation of conservation and development objectives presents significant challenges, with few cases demonstrating that they successfully meet all of the model's criteria [11–13]. In addition, the BR designation is relatively unknown to the public.

In 2016, Reed [8] pointed out that the purpose, activities, and potential benefits of BRs are also not well-known to scientists, policy makers, and local communities themselves and, as a result, the issues facing BRs are generally not considered in the research and action agendas of scientists or policy makers [14].

Through incorporating conservation areas recognized under other formal conservation designations, BRs seek to enhance the fulfillment of their objectives. However, overlapping designations do not guarantee a cumulative protective effort, as they may not favor existing

conservation areas, and continuous re-evaluation may be required [11]. The periodic review process—the mechanism for evaluation of BRs—is considered inadequate for monitoring the effectiveness of management, as it focuses primarily on assessing compliance with designation criteria, and not on management and governance performance [15].

Evaluating the effectiveness of the management of BRs, which is part of the MAB-UNESCO program, is an important element for understanding how governance models work in specific contexts. To maximize the potential of protected areas and optimize management processes, it is crucial to identify both their strengths and weaknesses, as well as the threats they face [16]. It is important to develop a comprehensive framework for the assessment of the management effectiveness of protected areas and their systems, providing guidance to managers and facilitating the harmonization of assessments globally.

The Management Effectiveness Tracking Tool (METT3), developed by the World Bank and the World Wildlife Fund (WWF), was designed to address the assessment elements included in the framework of the World Commission on Protected Areas (WCPA) [17] and includes the criteria of Context, Planning, Inputs, Processes, Outputs, and Outcomes, with 30 associated questions [17,18]. In the systematic review of empirical studies conducted to identify the main characteristics related to the effectiveness of BR management [13], researchers identified and agreed with METT on four main categories (context, inputs, process, and outputs), which interact at different scales and shape management effectiveness.

A key finding based on the results of assessments conducted using the METT methodology by the WWF in 2003 and 2004 in more than 200 protected areas in 34 countries [19], and in 2007 in over 330 protected areas in 51 countries [20], revealed that management effectiveness tended to increase with time after its establishment and was mostly associated with the strictest protection categories. In contrast, the presence of other designations, such as "World Heritage," UNESCO's "Man and the Biosphere," or the Ramsar Convention on Wetlands, showed no significant influence on management success [21]. In this sense, designations such as MAB-UNESCO are not binding, even though they are designated by national governments and are under the sovereign jurisdiction of the states in which they are located, and their status is internationally recognized [22]. It is likely that BRs that do not function according to the established criteria (i.e., that exist only on paper and not in practice) may be removed from the World Network of Biosphere Reserves [11].

In 2014, 3462 assessments of the general version of the METT were reported worldwide, but no public records can be found on the Protected Planet website, where the information is hosted. In the case of Mexico, between 2006 and 2017, METT assessments were carried out in 20 protected natural areas, all of which were under national management. None of them were carried out in Tamaulipas [23].

The Management Effectiveness Tracking Tool (METT) is widely used in a number of countries, often adapted to local needs. In its simplest form, using the METT can be a quick process. A single person—such as a protected area manager or a project manager with in-depth knowledge of the area—can complete the assessment in a few hours. The equipment required is minimal: a computer is ideal, but even a pen and paper will suffice for the paper version [24]. An excellent example of METT's adaptability comes from Papua New Guinea (PNG). In 2016, the government's Conservation and Environment Protection Authority (CEPA), with support from the United Nations Development Programme (UNDP) and the Secretariat of the Pacific Regional Environment Programme (SPREP), undertook an assessment of its protected areas to improve management effectiveness. As most of Papua New Guinea's PAs are located on land owned and managed by customary landowners who lack specialized government staff, it was necessary to adapt the METT to local conditions. This required the addition of explanatory notes to most of the assessment questions [25–27].

The establishment and maintenance of interdisciplinary research and action networks is necessary to follow up on the work carried out in BRs, and it requires the coordination of academic, governmental, and intergovernmental institutions; adequate recognition of this type of research; and the support of adequate resources and funding [7].

In Mexico, MAB-UNESCO was introduced in 1977, and it now includes 41 reserves in the country, including [28] the one in Tamaulipas, the CBR, which is highlighted [29], as it is the only one managed at the state level. This distinction makes the El Cielo Biosphere Reserve (CBR) a privileged case study. This study examines how it has implemented the MAB guidelines, including adapting to its complex institutional framework and its management program, and its associated achievements since its designation in 1986. Over the years, the CBR has been subject to various generations of UNESCO, as well as national and subnational government policies, yet the extent to which its management and orientation have evolved in response to these guidelines is unknown.

The significance of this study lies in the fact that an analysis is carried out in the specific context of the only state reserve that belongs to MAB-UNESCO.

The research question to be answered is as follows: To what extent does the CBR management program comply with functions in Art. 3 of the statutory framework of UNESCO's MAB Programme, and how has its management effectiveness evolved between 2017 and 2024? The main objective was to comprehensively assess compliance and analyze the evolution of its management effectiveness during the period of 2017–2024 using METT3. In this context, the following hypothesis is proposed: the CBR management program presents areas of opportunity to improve compliance with the functions specified in Article 3 of MAB-UNESCO, as it has undergone changes between 2017 and 2024, with a decreasing tendency in its management effectiveness.

2. Materials and Methods

2.1. Study Area

The CBR is located in the southwestern part of the state of Tamaulipas, Mexico, in the municipalities of Gómez Farías, Llera, Jaumave, and Ocampo, covering a portion of the Sierra Madre Oriental on the slopes known as Sierra de Cucharas or Sierra de Guatemala and Sierra Chiquita. It is located at the geographical coordinates between parallels 22°55′30″ and 23°25′50″ north (latitude), and meridians 99°05′50″ and 99°26′30″ west (longitude). It is limited to the north by the Guayalejo River, to the south by the municipality of Ocampo, to the east by the altitude of 200 m above sea level (in addition to the Sabinas River and its headwaters), and to the west by the semi-desert zone of Tula and the Jaumave Valley. It covers an area of 144,530.51 ha, with two core zones—core zone I, with 28,674.75 ha and core zone II, with 7844.31 ha, totaling 36,518.00 ha—and a buffer zone with 107,991.45 ha. The area of influence that was added to the conservation, management, and protection strategy in 2013 was 124,723.5 ha, thus expanding the protected area of the CBR to 269,253.5 ha [30]; see Figure 1.

The population of the CBR is 12,456 inhabitants, distributed in 74 communities of the 4 municipalities that make it up: Gómez Farías (20), Jaumave (25), Llera de Canales (20), and Ocampo (9). The population is concentrated in 40 towns (10 in the buffer zone and 30 in the zone of influence), where 84.82% (10,565) of the population lives (22); see Table 1.

Table 1. Demographic characterization of the CBR: distribution of localities and population by municipalities and zones.

Municipalities	Zone	Buffer	Influence	Total
Gómez Farías	Locations Population	4 1080	10 2015	14 3095
Jaumave	Locations Population	2 79	7 7530	9 7609
Llera	Locations Population	4 731	6 321	10 1052
Ocampo	Locations Population		7 700	7 700

Source: [31].

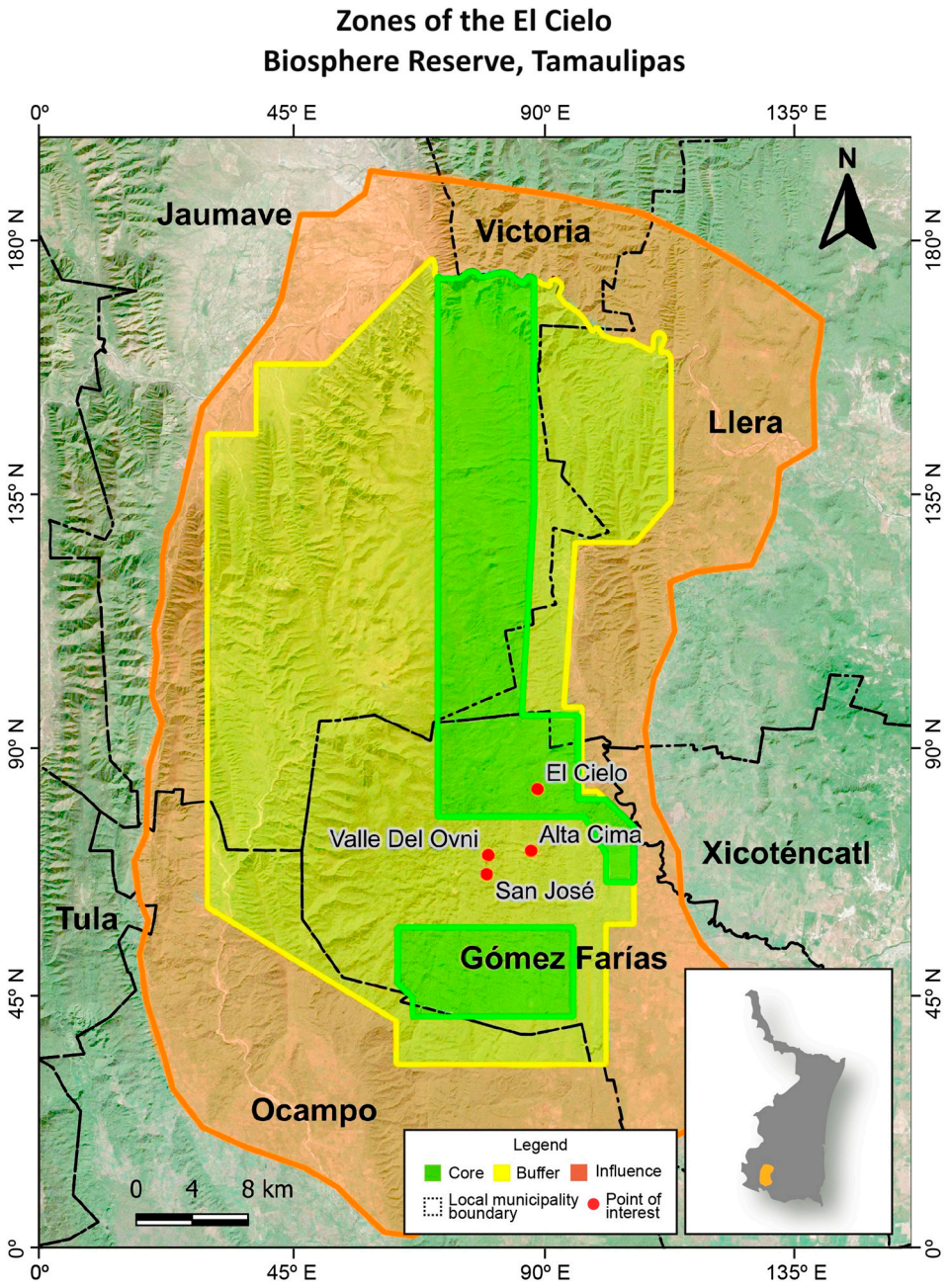

Figure 1. The CBR, illustrating core zones 1 and 2, the buffer zone, and the zone of influence. Source: prepared by the authors based on information from the decree creating the CBR and the 2013 management program.

The Social Gap Index (IRS) 2020 by CBR zones shows that, of the 40 communities, 80% present a very low or low social gap [32] and 80% present very low or low social backwardness (Table 2). The IRS provides information on four social deprivations regarding CONEVAL's poverty measurement: educational backwardness, access to health services, access to basic services in housing and quality, and spaces in housing. The IRS 2020 estimates were generated based on the 2020 Population and Housing Census [31].

Table 2. Social Gap Index (2020) by zone of the CBR.

Zone	Very Low	Under	Medium	High	Very High
Buffer	4	2	1	2	1
Influence	14	12	4	0	1
Total	18	14	5	2	2

Source: [31].

2.2. Methods and Data Analysis Techniques

The research design was a mixed-methods exploratory sequential design [33], characterized by its flexible and rigorous approach to research, combining qualitative and quantitative methods to provide a deep and complete understanding of the phenomenon under study. This design differs from other mixed methods in that it is structured in two sequential phases: Phase 1—qualitative exploration and Phase 2—quantitative analysis. The findings from both phases are compared and integrated to produce a more complete and nuanced interpretation of the phenomenon. Qualitative findings enrich the understanding of quantitative data, while the latter bring rigor and generalizability to the qualitative findings [34–36]; see Figure 2.

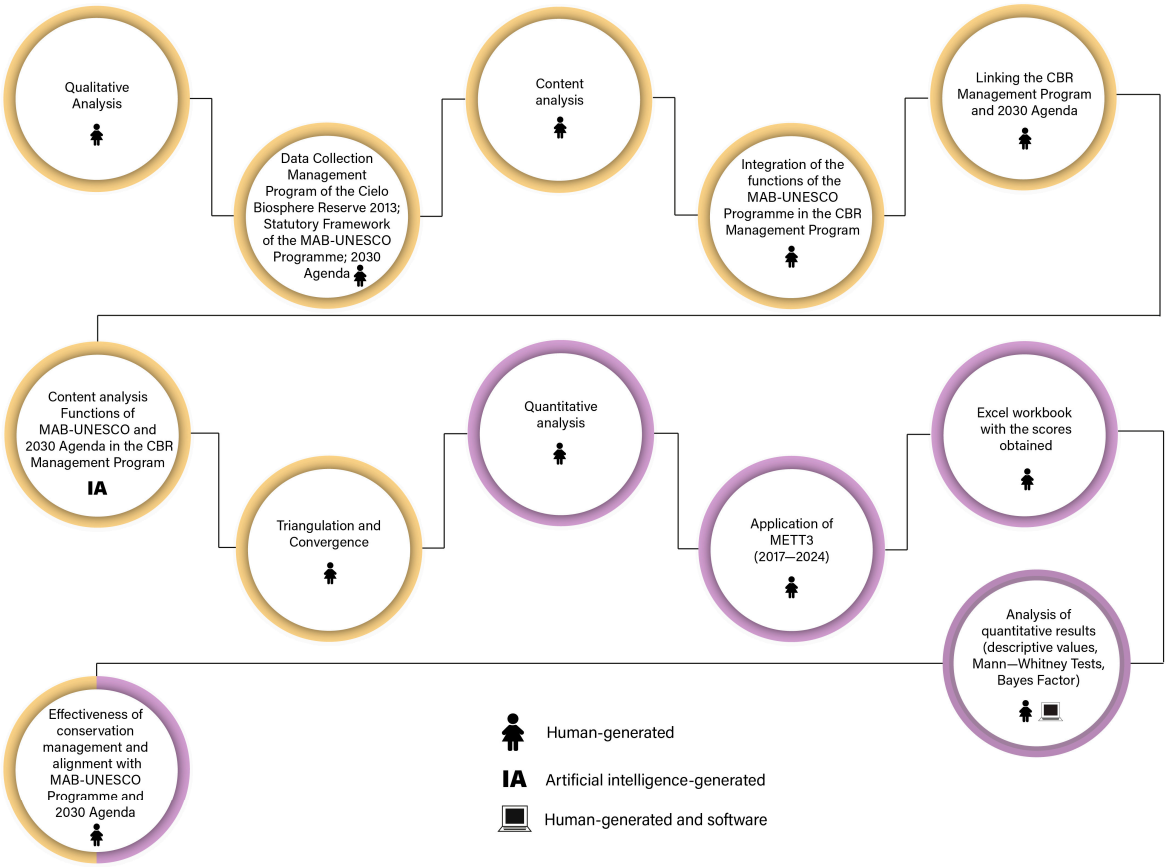

Figure 2. Diagram of the mixed-methods sequential exploratory research methodology, indicating the qualitative stages, human work, and use of technology.

Qualitative analysis

A. A document search was conducted in electronic sources of the government of the state of Tamaulipas related to the CBR and the MAB-UNESCO program. The documents selected for an exhaustive manual human analysis were as follows:

- The management program of the El Cielo Biosphere Reserve (CBR) 2013 [30];
- The *Statutory Framework of the World Network of Biosphere Reserves* [5];

- *A New Roadmap for the Man and the Biosphere (MAB) Programme and its World Network of Biosphere Reserves, MAB Strategy (2015–2025), Lima Action Plan for UNESCO's Man and the Biosphere (MAB) Programme and its World Network of Biosphere Reserves* (2016–2025) [1,5,22,37];
- The 2030 Agenda for Sustainable Development [38].

B. A comprehensive manual human content analysis of the documents was conducted to characterize the following:
   - Integration of the functions of the MAB-UNESCO program into the CBR management program;
   - Linkage of the CBR management program with the 2030 Agenda for Sustainable Development.

C. To complement and enrich the human analysis, reduce the biases inherent in manual analysis, and strengthen the evaluation, an artificial intelligence (AI) program was used. Gemini, a large language model developed by Google AI, is characterized by its ability to perform complex tasks such as summarizing text, answering questions comprehensively, and generating different creative text formats [31]. A content analysis of the management program of the El Cielo Biosphere Reserve (CBR) [30], the functions established in Art. 3 of the statutory framework of the UNESCO MAB Programme [1,5,22,37], and the goals of the 2030 Agenda was carried out. To this end, the following guiding questions were posed:
   - To what extent does the current management program of the El Cielo Biosphere Reserve (CBR) fulfill the functions established in Art. 3 of the statutory framework of the UNESCO MAB Programme?
   - To what extent does the CBR management program address the conservation challenges envisaged in the 2030 Agenda and emerging trends in protected area management?

D. Triangulation and convergence were performed. The confrontation and combination of analyses from human manual assessment and artificial intelligence (AI) yields more reliable and accurate approximations. Triangulation, which involves integration, strengthens the validity and reliability of results by reducing the bias inherent in any single approach. It also facilitates the identification of consistencies and discrepancies which, in turn, improves the understanding of complex phenomena and allows for a more complete and robust assessment.

Quantitative analysis

In this phase, a rapid assessment of the management effectiveness of the El Cielo Biosphere Reserve (CBR) was carried out through the application of the standardized METT3 (Management Effectiveness Tracking Tool) [17] (Table 3).

METT3 was chosen, despite the existence of a more recent version (METT4), to maintain methodological consistency and comparability with the previous assessment carried out in 2017. It is recognized that the way in which it is completed may vary depending on the circumstances and time available; it may be answered by the director of an NPA, and it may be a participatory assessment. In this study, it was decided that the survey would be applied individually to actors from different sectors related to the CBR. This strategy allowed us to obtain a broader and more contrasting view of the reserve's management effectiveness, considering the perspectives of several relevant stakeholders. The METT3 tool determines the order of the questions according to the element being evaluated.

Snowball sampling was used for data collection, a non-probabilistic strategy that facilitates access to hard-to-reach populations [32]. This type of snowball sampling can be useful for generating hypotheses and obtaining an overview of the phenomenon and was the only viable strategy to access this population.

Table 3. Summary of the elements of the WCPA framework and the criteria that can be assessed. The World Bank/WWF Management Effectiveness Tracking Tool was designed to address the assessment elements included in this framework.

Elements of Evaluation	Explanation	Criteria That Are Assessed	Focus of Evaluation	Questions
Context	*Where are we now?* Assessment of importance, threats, and policy environment	Significance Threats Vulnerability National context Partners	Status	1. Legal status
Planning	*Where do we want to be*? Assessment of protected area design and planning	Protected area legislation and policy Protected area system design Reserve design Management planning	Appropriateness	2. Protected area regulations 4. Protected area objectives 5. Protected area design 8. Regular work plan 21. Planning for land and water use Monitoring and evaluation
Inputs	*What do we need?* Assessment of resources needed to carry out management	Resourcing of agency Resourcing of site	Resources	3. Law enforcement 9. Resource inventory 13. Staff numbers 14. Staff training 15. Current budget 16. Security of budget 18. Equipment 29. Fees
Processes	*How do we go about it?* Assessment of the way in which management is conducted	Suitability of management processes	Efficiency and appropriateness	6. Protected area boundary demarcation 7. Management plan 10. Protection systems 11. Research 12. Resource management 14. Staff training 17. Management of budget Maintenance of equipment 20. Education and awareness 22. State and commercial neighbors 23. Indigenous people 24. Local communities Monitoring and evaluation 28. Commercial tourism operators 29. Fees
Outputs	*What were the results?* Assessment of the implementation of management programs and actions; delivery of products and services	Results of management actions Services and products	Effectiveness	8. Regular work plan 27. Visitor facilities
Outcomes	*What did we achieve?* Assessment of the outcomes and the extent to which objectives were achieved	Impacts: effects of management in relation to objectives	Effectiveness and appropriateness	10. Protection systems 25. Economic benefit 30. Condition of values

Source: [17].

The criteria established for inclusion were the same as in 2017, which sought to ensure that participants were aware of the CBR and its processes:

- Community: Have at least five years of permanent residence in one of the CBR localities.
- Government: Work or have worked within the last five years in state or municipal government departments in areas related to the CBR.
- Researchers: Have developed or are developing at least two research projects at the CBR within the last five years.

Initial participants were identified and invited to participate in the study. Once their informed consent was obtained, they were asked to recommend others with similar characteristics to expand the sample. The average time to administer the survey to each participant was 90 min.

Despite the small sample size of 30 (15 in 2017 and 15 in 2024), we consider the data obtained valuable for exploring the initial experiences of this group, gaining an overview of the phenomenon, and generating hypotheses for future large-scale research.

It is important to recognize the inherent limitations of snowball sampling, primarily related to selection bias. When relying on personal references to identify participants, there is a possibility that the sample may be biased towards certain groups or types of individuals, which could affect its representativeness of the target population. In addition, the lack of generalizability is another important limitation. Due to selection bias, the results of a convenience sample cannot be generalized in the same way as those of a random sample. This limits the applicability of the findings to larger populations and calls for caution when extrapolating conclusions. Consequently, caution must be exercised when drawing broader conclusions.

The instrument was administered in 2017 and 2024 to 15 people each time, as detailed in Table 4.

Table 4. Characterization of participants in the application of METT3 in 2017 and 2024.

Year of Application	Sector	Gender		Age				Education Level			
		Female	Male	21–30	31–40	41–50	51 and above	No Degree	Bachelor's Degree	Master's Degree	PhD
2017	Government (n = 3)	3			1	1	1		3		
	Community (n = 5)	2	3		1	3	1	5			
	Research (n = 7)	2	5		2	2	3			1	6
	Total	7	8		4	6	5	5	3	1	6
2024	Government (n = 5)	3	2		2	2	1		3	1	1
	Community (n = 5)	4	1	1	1	1	2	4	1		
	Research (n = 5)	2	3		1		4			2	3
	Total	9	6	1	4	3	7	4	4	3	4

In order to protect the anonymity of the respondents, in accordance with the Helsinki protocol, they were identified by the sector in which they participated rather than by their institution, age, level of education, or gender [39]. Preservation of anonymity does not preclude an integrated and accurate presentation of the analysis. To maintain consistency in the clarification of doubts and guidance required by participants, the survey was administered by the same person who administered it in 2017 [40].

The assessment was carried out by assigning a simple score ranging between 0 (poor) and 3 (excellent). A series of four alternative answers were provided for each question, helping the assessors to make judgements regarding the level of the score given. In addition, there were supplementary questions that elaborated on key themes from the previous questions and provided additional information and points. The maximum score for the 30 questions and supplementary questions is 99. A final total of the score from the completed assessment form can be calculated as a percentage of 99 or by the total score from those questions that were relevant to a particular protected area. In this case, question 23 was removed as there are no indigenous groups in the CBR (Table 3).

In each evaluation, 15 participants were surveyed, such that the total score that could be obtained would be 1485 in total, providing a basis for determining the effectiveness of CBR management in 2017 and/or 2024.

With the data from the 2017 and 2024 surveys, an Excel workbook was generated and filled with the data from the 30 questions and the answers from the 30 surveys. Subsequently, the information from the METT3 survey carried out in 2017 by 15 people was analyzed and contrasted with that of 2024, carried out by another 15 (different) people [40].

First, an exploratory and descriptive analysis of the data was performed. A normality test (Shapiro–Wilk (SW)) was applied; however, as the sample was small and no evidence of normal distribution was found in the responses to be analyzed, it was decided to use non-parametric statistics. The Mann–Whitney (MW) test was used to assess the differences in the responses of the two different groups of people [41]. In this case, comparisons were made considering that they are two independent groups (as the participants differed between 2017 and 2024) in two different periods. For this purpose, *p*-values were used to determine whether there were differences in the management effectiveness of the CBR between 2017 and 2024. Statistically significant differences were considered to exist when the *p*-value was less than 0.05, as a 95% confidence level was used.

Thus, when comparing the responses between 2017 and 2024, significant statistical differences were considered only in cases when the MW test result was $p < 0.05$. For the rest of the questions (i.e., those with *p*-values greater than 0.5), it was not possible to make conclusions about statistical differences, even when there were numerical differences in the mean or median for the descriptives. To complement the *p*-value, the effect size (biserial rank correlation) was also calculated, as well as the Bayes factor, which quantifies the magnitude of the evidence in favor of the research hypothesis. Jamovi version 2.3.28.0 [42] was used for all quantitative data analyses.

In a second phase of quantitative analysis, oriented to reveal the evolution of management effectiveness according to the evaluation element, the data from the 2017 and 2024 surveys were integrated according to the original definition of the METT3 instrument—Context, Planning, Inputs, Processes, Outcomes, and Outputs—considering its 30 questions (Table 3) and answers from the 30 interviewees. Thus, aggregated scales were calculated according to the questionnaire (Zikmund, 2013) [43], using grouped or summed scales obtained by adding the scores of several items in the questionnaire.

A review of assumptions was made, in order to be able to perform the analysis of these comparisons with grouped items; for this purpose, Cronbach's alpha and McDonald's w were calculated. In all cases, acceptable values were obtained (>0.80) to be able to group the questions and proceed with the analysis. For comparisons, the Mann–Whitney U-test was also conducted [41], in order to determine significant statistical differences, where significance was determined by $p < 0.05$. Similarly, the effect size (biserial rank correlation) and the Bayes factor were calculated.

3. Results

3.1. A Comprehensive Manual Human Content Analysis: Integration of the Functions of the MAB-UNESCO Programme into the CBR Management Program

Since its decree as a protected natural area (PNA) in 1985 [44], the CBR has been governed by three management programs. In 1986, the first integrated management plan for the CBR was published; the second was published in 1996, and the third in 2013.

The 2013 management program is conceptualized as the "guiding document for planning and regulation of the CBR, it establishes the actions through which the objectives of conservation of its biodiversity and ecosystems are intended to be achieved, supported by management, research and dissemination, also integrating the mechanisms and strategies necessary for the proper management and administration of the area, all in congruence with the National Development Plan 2013–2018, the National Program of Natural Protected Areas 2013–2018, the National Biodiversity Plan and the State Development Plan 2011–2016" [30].

The general objective of the management program is to promote the concept of the protected area and its areas of influence and external areas as a multi-dimensional geographical space with a focus on sustainable regional development, through which ecological, social, cultural, and economic benefits are generated to guarantee the connectivity and functionality of ecosystems, with a participatory, respectful, and inclusive vision of all sectors of society. It also establishes eight specific objectives derived from the general one.

Six conservation subprograms have been established, each with specific components, objectives, targets, activities, and actions based on a diagnosis of the area's ecosystems, biodiversity, problems, and conservation needs. Each subprogram is assigned a specific percentage within the CBR management program, distributed as follows: 1. Protection (14.29%); 2. Management (22.67%); 3. Restoration (6.83%); 4. Knowledge (9.94%); 5. Culture (7.76%); and 6. Management subprogram (38.51%). The actions and activities are planned to be developed in different time frames: short-term (41%), between one and two years; medium-term (23.91%), between three and four years; and long-term (2.8%), exceeding five years; as well as the category of permanent (31.98%) actions or activities, which are to operate for an indefinite period [25].

The Management subprogram establishes that the council "is the permanent management body whose purpose is to implement the management program, to supervise and monitor compliance with the rules established in the Declaration, and to approve the conservation, management and sustainable use activities proposed in the CBR Annual Operational Program and is responsible for reporting to the appropriate authorities on the results or any other matter related to the CBR".

The council is composed of technical and representative members, as well as a technical secretariat which, in turn, is composed of coordinators according to the 44 components of the subprograms: Protection (6), Management (10), Restoration (5), Knowledge (4), Culture (5), and Governance (14).

The director of the CBR is the institutional figure in charge of the management of the CBR, in accordance with the provisions of the LGEEPA, the ANP regulations, the decree creating the CBR, and the administrative norms of the current management program. With the creation of the CBR, in 2022, the first coordinator was appointed, who reports to the Directorate of Natural Resources and Natural Areas Management of the Secretariat of Urban Development and Protected Environment, whose office is in the state capital.

To achieve the objectives of the CBR, it is important to promote interinstitutional and interdisciplinary work to optimize the management of natural resources and improve the quality of life of local inhabitants. To this end, it promotes links and coordination at the international level with state, federal, and municipal sectors, as well as with the academic, private, and civil sectors. This will make it possible to achieve the objectives of each subprogram.

The overall management program should be evaluated at least every three years. The evaluation process should be comprehensive and participatory, involving all sectors of

society related to the CBR. Local and federal organizational structures, such as CARBEC and the State Commission of Protected Natural Areas (CEANP), are used for this purpose. Finally, formal proposals to modify the management program should be implemented through appropriate legal and administrative procedures.

The CBR is associated with other national and international designations; however, of these, only the protected natural area has a legal basis. Aside from its MAB-UNESCO status, designated in 1986 [29], as mentioned in the management program, it is also an IBA (ID: MX085) [45], KBA (ID: 10067) [46], and Priority Terrestrial Region of Mexico [47].

A manual content analysis of both documents was conducted, which allowed us to assume that the management program of the El Cielo Biosphere Reserve (RBEC), approved in 2013, is largely consistent with the statutory framework of the UNESCO MAB Program, as it sets clear objectives for the conservation of the Reserve's biodiversity. An approximation of this analysis is provided in Table 5.

Table 5. Integration of the CBR management program with the functions indicated in Art. 3 of the statutory framework of MAB-UNESCO.

Theme	Theme Description	Examples in the Management Program
Conservation	Contribute to the conservation of landscapes, ecosystems, species, and genetic diversity.	Specific objective: To regulate productive activities such that they are compatible with the objectives of conservation and protection of natural resources and biodiversity; it includes six conservation subprograms.
		Protection: Specific programs for the protection of species under risk categories; identification of new fragile and priority conservation areas and ecosystems based on studies.
		Management: Conversion of agricultural and livestock activities within a framework of sustainability; conservation of riparian corridors and river systems.
		Restoration: Restoration projects in fragmented and degraded areas; adoption of new practices and technologies for sustainable use and management of freshwater, surface water, groundwater, and soils.
		Knowledge: Conservation status of natural resources; comprehensive study of water quality indicator species, identifying possible long-term threats, and proposing necessary conservation, mitigation, or restoration measures.
		Culture: Environmental education programs; community and volunteer participation in environmental education, conservation, and sustainable use activities.
Development	Promote socio-cultural and environmentally sustainable economic and human development.	Specific objective: Promote economic, administrative, and educational activities to improve the quality of life of resident communities within a sustainable environmental framework; it proposes actions in subprograms.
		Management: Development plans and evaluation of productive alternatives; training for ecotourism services.
		Restoration: Alternative projects for the propagation and reproduction of plants and animals of commercial value or for self-consumption; oriented towards a conservationist vision but generating economic income.
		Knowledge: Integration of a regional information system regarding the values of the reserve with the participation of the communities; promotion of the regional culture and its dissemination among the population of the CBR.
		Culture: Involve local communities in decision making; provide ongoing non-formal and formal environmental education for conservation.
		Management: Participatory planning in CBR management processes; promoting cooperation between academic institutions, service providers, and non-governmental organizations.

Table 5. *Cont.*

Theme	Theme Description	Examples in the Management Program
Logistical Support	Support demonstration projects, environmental education and training, and ongoing research and monitoring related to local, regional, national, and global conservation and sustainable development issues.	Specific objective: To promote scientific research and conservation education for knowledge of ecosystems and sustainable use, and to raise public awareness of and respect for natural resources.
		Protection: Identify alternatives to produce electrical energy to mitigate climate change; develop plans and projects to generate data, inventories, and strategies for environmental monitoring of aquatic ecosystems.
		Restoration: Reproduction and sustainable management for the propagation and reproduction of native plants and animals of commercial or subsistence value, as well as reforestation processes that apply the ecological principles of restoration and its dynamics.
		Knowledge: Carry out actions to disseminate research and monitoring work in the CBR; define and generate new lines of research in accordance with the priorities of the NPA and identify possible sources of funding.

3.2. A Comprehensive Manual Human Content Analysis on Linkage of the CBR Management Program with the 2030 Agenda for Sustainable Development

The Sustainable Development Goals (SDGs) of the 2030 Agenda were adopted by all United Nations member states on 25 September 2015. This adoption took place during the United Nations Summit on Sustainable Development in New York. The 2030 Agenda, which includes the 17 SDGs, entered into force on 1 January 2016. The management program was published on 28 November 2013, so it is not considered, nor are its goals, targets, and actions.

A search was made for concepts in the CBR management program that are present in the MAB-UNESCO roadmap strategies of 2015–2025, and the Plan of Action for Lima 2025. The following results were obtained: Aichi Targets (0); Convention on Biological Diversity (CBD) (0); ecosystem approach (0); ecosystem services (0); ecosystem services (0); environmental services (17); ecosystem-based management (0); education for sustainable development (ESD) (0); environmental education (17); ESD Global Action Program (0); Global Framework for Climate Services (0); the United Nations Framework Convention on Climate Change (UNFCCC) (0); Climate change mitigation and adaptation component Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Ramsar Convention); Reducing Emissions from Deforestation and Forest Degradation (Restoration sub-program, Deforestation) (14); Science diplomacy (0); Sustainability science (0); Sustainable Development Goals (0); UNESCO Associated Schools Project Network (ASPnet); (0) UNITWIN (0); UNESCO Chairs Program (0); Community resilience (0); and Connectivity and landscape ecology—Corridors component for the restoration of riparian corridors and river systems.

3.3. Analysis Using Artificial Intelligence (AI)

To what extent does the current management program of the El Cielo Biosphere Reserve (CBR) fulfill the functions established in Art. 3 of the Statutory Framework of the UNESCO MAB Programme?

Article 3 of the statutory framework of the MAB-UNESCO Programme establishes the functions of biosphere reserves, which are closely aligned with the current CBR management program. A detailed analysis of the alignment of the program with each of the functions is presented below:

Conservation of biological diversity and cultural values: (a) establishes clear objectives for the conservation of the rich biodiversity of the CBR, including the protection of endangered species, restoration of degraded ecosystems, and sustainable management of natural resources; (b) recognizes the importance of the region's cultural heritage and

encourages initiatives for its conservation and promotion; and (c) includes actions to protect archeological sites, local traditions, and cultural expressions.

Integrate biodiversity conservation with the sustainable socio-economic development of local communities: (a) includes strategies to generate sustainable economic opportunities, improve the quality of life of communities, and strengthen their participation in the management of the reserve; (b) promotes the rational and sustainable use of natural resources to ensure their availability for present and future generations; and (c) includes actions to reduce pollution, encourage sustainable agricultural practices, and promote the efficient use of water.

Support for scientific research and systematic monitoring: (a) recognizes the importance of scientific research to understand the dynamics of CBR ecosystems and to guide conservation and management actions; (b) establishes priority lines of research and encourages collaboration between scientific institutions and local communities; (c) includes a monitoring plan to evaluate the biodiversity status, ecosystems, and the impacts of conservation actions; and (d) data obtained are used to adapt management strategies and ensure compliance with conservation objectives.

The current management program of the CBR represents a significant advance in the implementation of the functions of the MAB-UNESCO Programme.

To what extent does the CBR management program address the conservation challenges envisaged in the 2030 Agenda and emerging trends in protected area management?

While the current CBR management program, approved in 2013, has laid the groundwork for biodiversity conservation and sustainable development in the region, its relevance to address the challenges foreseen in 2030 requires a thorough critical evaluation.

It is considered that a comprehensive assessment should (a) be aligned with relevant international goals and targets for the next decade, such as the Sustainable Development Goals (SDGs) and the Aichi Biodiversity Targets; (b) integrate a thorough analysis of the potential impacts of climate change on the CBR's ecosystems and communities; (c) promote an integrated approach that combines biodiversity conservation with the sustainable socio-economic development of local communities; and (d) consider the adoption of new technologies and protected area management approaches that have been proven effective in other contexts, such as the use of remote monitoring systems, the application of citizen science, and the implementation of innovative financing mechanisms. The management program should be a dynamic and flexible document that is periodically reviewed and updated to reflect changes in the environmental, social, and economic contexts.

3.4. Triangulation and Convergence

A comparative analysis of the results obtained manually by human experts and those generated using artificial intelligence methods was carried out to answer the posed questions. The results of the two methods were triangulated and manually converged by the four experts, a member of a public sector, a researcher, a member of an NGO, and a community member. This process made it possible to identify coincidences and discrepancies, in order to complement the perspectives of both methodologies. The results are detailed in Tables 6 and 7.

Table 6. To what extent does the current management program of the El Cielo Biosphere Reserve (CBR) fulfill the functions established in Art. 3 of the statutory framework of the UNESCO MAB Programme?

Categories	Manually Generated	Artificial Intelligence-Generated
Approach	Evaluation of the consistency of the management program with the guidelines of the MAB-UNESCO Programme, with particular emphasis on alignment with the conservation objectives and the provisions of Article 3 of the statutory framework.	Identification of current problems and challenges facing the RBEC in its management and conservation. More emphasis on socio-economic aspects and budgetary constraints.
Objectives and programs	Detailed analysis of specific objectives and management subprograms, focusing on protection, restoration, and monitoring actions.	Identification of general problems and challenges without detailing specific programs.
Zoning	Quantitative and qualitative evaluation of the area's zoning, including analysis of the protected area, the distribution of core and buffer zones, and the evolution of these parameters over time.	It does not address specific zoning details.
Depth	Detailed evaluation of management functions and subprograms, highlighting specific objectives and concrete examples.	It provides a broader and more general view of the problems and challenges.
Evaluations	Historical review of evaluations and compliance with the UNESCO framework. Specific mention of compliance (or lack thereof) with the ten-year evaluations.	It does not address the history of compliance but the current conditions.
Perspective	Normative and technical evaluation of the management program, based on an exhaustive review of existing documentation and within the framework of international standards for protected area management.	Broad narrative overview, identifying challenges and constraints efficiently and quickly, albeit with less detail and structure.

Table 7. To what extent does the CBR management program address the conservation challenges envisaged in the 2030 Agenda and emerging trends in protected area management?

Categories	Manually Generated	Artificial Intelligence-Generated
Approach	Review of the historical context on the adoption of the Sustainable Development Goals (SDGs) in 2015 and the publication of the management program in 2013, highlighting that the SDGs are not covered in the management program due to their earlier publication date. It focuses on the alignment of the management program with the regulatory framework and conservation objectives.	Prospective approach, focuses on the relevance of the management program to address the challenges until 2030, suggesting the need for a comprehensive critical evaluation. Emphasizes the importance of integrating biodiversity conservation with the sustainable socio-economic development of local communities.
Depth concept search	Analysis of key concepts in the management program that are relevant to global strategies, such as the Aichi Targets, the Convention on Biological Diversity, and others, highlighting the absence or presence of these terms. Includes detailed information on the zoning and area of the reserve, showing a thorough understanding of the structure of the management program.	It determines general considerations and suggestions for a comprehensive evaluation without going into specific details on the presence of terms or zoning.
Evaluation and updating	Analysis of previous evaluations and reporting delays, providing a historical and policy context. It identifies the need for a comprehensive assessment to update the management program and incorporate the SDGs and other global frameworks but does not explicitly discuss the need for flexibility and adaptability of the document.	Proposes that a comprehensive assessment that should align with the SDGs and the Aichi Targets, integrate a climate change impact analysis, promote an integrated approach to conservation and development, and consider new technologies and management approaches. It recommends the need for a dynamic and flexible management program, periodically reviewed and updated to reflect contextual changes.
Perspective	Detailed and specific analysis of the management program's alignment with global frameworks and provides historical and regulatory context. Focuses on the need for updating to incorporate SDGs and other relevant frameworks.	It presents a prospective and general approach, suggesting considerations for a comprehensive evaluation and proposing technological improvements and socio-economic integration.

3.5. Evaluating the Effectiveness of CBR Management

The effectiveness of CBR management in 2017 and 2024, according to the METT3 evaluation criteria (i.e., Context, Planning, Inputs, Processes, Outputs, and Outcomes) presented a downward trend, as the percentages obtained from the responses of the interviewees in the 2017 and 2024 evaluations were 44.78% and 29.62%, respectively (Table 8).

Table 8. Characterization of the responses obtained through the questionnaires issued in 2017 and 2024.

Questions	Years	Points Obtained	Mean	Std. Deviation	Median	IQR	Shapiro–Wilk	*p*-Value of Shapiro–Wilk
Q1	2017	43	2.867	0.352	3	0	0.413	<0.001
	2024	41	2.733	0.458	3	0.5	0.561	<0.001
Q2	2017	29	1.933	0.799	2	1.5	0.817	0.006
	2024	14	0.933	0.458	1	0	0.631	<0.001
Q3	2017	20	1.333	0.976	2	1.5	0.84	0.013
	2024	14	0.933	0.594	1	0	0.763	0.001
Q4	2017	25	1.667	0.816	2	0.5	0.749	<0.001
	2024	17	1.133	0.834	1	1.5	0.799	0.004
Q5	2017	29	1.933	0.704	2	0	0.702	<0.001
	2024	31	2.067	0.594	2	0	0.763	0.001
Q6	2017	28	1.867	0.834	2	1.5	0.799	0.004
	2024	20	1.333	0.724	1	1	0.817	0.006
P7	2017	29	1.93	0.7	2	0.5	0.82	0.006
P7	2024	25	1.67	0.49	2	1	0.6	<0.001
Q7a	2017	3	1	0	1	0	Cannot be calculated	Cannot be calculated
	2024	5	1	0	1	0	Cannot be calculated	Cannot be calculated
Q8	2017	17	1.133	0.99	1	1	0.847	0.016
	2024	7	0.467	0.64	0	1	0.713	<0.001
Q9	2017	28	1.867	0.64	2	0.5	0.79	0.003
	2024	16	1.067	0.799	1	1.5	0.817	0.006
Q10	2017	16	1.067	1.033	1	1.5	0.842	0.014
	2024	5	0.333	0.488	0	1	0.603	<0.001
Q11	2017	27	1.8	0.676	2	1	0.801	0.004
	2024	26	1.733	0.704	2	0.5	0.771	0.002
Q12	2017	26	1.733	1.033	1	2	0.812	0.005
	2024	16	1.067	0.884	1	2	0.782	0.002
Q13	2017	24	1.6	0.828	2	1	0.883	0.052
	2024	14	0.933	0.258	1	0	0.284	<0.001
Q14	2017	33	2.2	1.082	3	2	0.721	<0.001
	2024	16	1.067	0.704	1	0.5	0.815	0.006
Q15	2017	19	1.267	0.884	1	0.5	0.809	0.005
	2024	4	0.267	0.458	0	0.5	0.561	<0.001
Q16	2017	16	1	1.069	1	1.5	0.826	0.008
	2024	3	0.2	0.414	0	0	0.499	<0.001
Q17	2017	16	1.067	0.884	1	1	0.868	0.031
	2024	5	0.333	0.617	0	0.5	0.606	<0.001
Q18	2017	18	1.2	0.941	1	1.5	0.88	0.048
	2024	11	0.733	0.884	0	1.5	0.734	<0.001

Table 8. *Cont.*

Questions	Years	Points Obtained	Mean	Std. Deviation	Median	IQR	Shapiro–Wilk	*p*-Value of Shapiro–Wilk
Q19	2017	17	1.133	0.99	2	2	0.68	<0.001
	2024	1	0.067	0.258	0	0	0.284	<0.001
Q20	2017	22	1.467	0.743	1	1	0.861	0.025
	2024	2	0.133	0.516	0	0	0.284	<0.001
Q21	2017	0	0	0	0	0	NaN	NaN [a]
	2024	0	0	0	0	0	NaN	NaN [a]
Q22	2017	21	1.4	1.056	1	1	0.876	0.041
	2024	17	1.133	0.743	1	1	0.817	0.006
Q24	2017	23	1.533	1.125	1	1.5	0.87	0.034
	2024	6	0.4	0.737	0	0.5	0.596	<0.001
Q25	2017	27	1.8	1.082	2	1	0.817	0.006
	2024	16	1.067	1.223	1	2	0.789	0.003
Q26	2017	15	1	0.845	1	0.5	0.837	0.011
	2024	17	1.133	0.64	1	0.5	0.79	0.003
Q27	2017	26	1.733	0.594	2	1	0.758	0.001
	2024	23	1.533	0.743	2	1	0.861	0.025
Q28	2017	23	1.533	0.99	1	1	0.887	0.061
	2024	5	0.333	0.617	0	0.5	0.606	<0.001
Q29	2017	11	0.733	1.1	0	1	0.702	<0.001
	2024	14	0.933	0.961	1	1.5	0.844	0.014
Q30	2017	34	2.267	0.799	2	1	0.783	0.002
	2024	13	0.867	0.99	0	2	0.68	<0.001

[a] All values are identical.

Regarding the evaluation of the management effectiveness of the CBR in 2017 and 2024, Table 6 shows consistent trends of deterioration in 24 of the 30 questions asked, while 4 remained unchanged (Q2: regulations, Q5: design of the protected area, Q11: research, and Q26: monitoring and evaluation), and only 1 increased its score (Q29: tariffs).

Analysis of METT3 responses obtained in 2017 and 2024

Statistically significant differences ($p < 0.05$) between the responses of the two groups corresponded to Q2 (regulations), Q8 (periodic work plan), Q9 (resource inventory), Q10 (protection systems), Q13 (personnel), Q14 (personnel training), Q15 (current budget), Q16 (budget security), Q17 (budget management), Q19 (equipment maintenance), Q20 (education and awareness), Q24 (local communities), Q28 (commercial tour operators), and Q30 (condition of values); see Table 9. The effect size was medium to large for these questions—Q2 (0.662), Q15 (0.671), Q19 (0.569), Q20 (0.84), Q28 (0.68), and Q30 (0.693)—suggesting that these differences are real and have high significance in practice. The high value of the Bayes factor obtained for these questions provides further confirmation. Thus, the obtained evidence favors the research hypothesis.

Table 9. Statistical results of the comparison of the questionnaire applications in 2017 and 2024 through Mann–Whitney tests.

Questions	W	*p*	Effect Size (Rank-Biserial Correlation)	SE Rank-Biserial Correlation	Bayes Factor
Q1	127.5	0.386	0.133	0.211	0.47
Q2	187	<0.001	0.662	0.211	99.89
Q3	143	0.185	0.271	0.211	0.69
Q4	152	0.076	0.351	0.211	1.09
Q5	105	0.719	−0.067	0.211	0.39
Q6	151	0.086	0.342	0.211	1.25
Q7	115	0.93	0.022	0.211	0.59
Q7a	*	*	*	*	*
Q8	157.5	0.046	0.4	0.211	1.96
Q9	170.5	0.01	0.516	0.211	8.31
Q10	160	0.032	0.422	0.211	3.15
Q11	113.5	0.981	0.009	0.211	0.35
Q12	150.5	0.105	0.338	0.211	1.30
Q13	168.5	0.006	0.498	0.211	7.55
Q14	177.5	0.005	0.578	0.211	17.41
Q15	188	<0.001	0.671	0.211	49.48
Q16	163.5	0.017	0.453	0.211	4.56
Q17	168	0.013	0.493	0.211	4.05
Q18	143.5	0.18	0.276	0.211	0.72
Q19	176.5	0.001	0.569	0.211	68.12
Q20	207	<0.001	0.84	0.211	3408.11
Q22	126	0.568	0.12	0.211	0.44
Q24	178.5	0.004	0.587	0.211	13.19
Q25	150	0.11	0.333	0.211	1.05
Q26	97	0.487	−0.138	0.211	0.38
Q27	129	0.458	0.147	0.211	0.44
Q28	189	<0.001	0.68	0.211	60.46
Q29	94	0.419	−0.164	0.211	0.38
Q30	190.5	<0.001	0.693	0.211	113.05

* This question was optional, so not all participants answered it.

Trends

1. There was a general decline in management effectiveness (2024 vs. 2017). Most of the areas assessed showed a decline in management effectiveness scores between 2017 and 2024. This suggests increasing challenges or management changes that have failed to maintain or improve on previous standards.

2. The areas of greatest decline are detailed below.

Regulations: A significant decrease from 64.44% to 31.11% was observed. This may indicate changes in regulation or enforcement that have negatively affected effectiveness.

Personnel: The decrease from 53.33% to 31.11% suggests potential problems with staff retention, training, or, possibly, reductions in the workforce.

Current budget and budget security: These areas have seen drastic reductions, from 42.22% to 8.89% and from 35.56% to 6.67%, respectively. This indicates serious financial constraints that could be limiting operating capacity.

Protection systems: This area decreased from 35.56% to 11.11%.

Education and awareness: The decrease from 48.89% to 4.44% is alarming and could have a lasting impact on public perception and local support for conservation initiatives.

Equipment maintenance and budget management: These areas also presented significant decreases, which could affect the ability to conduct essential research and maintain critical operations.

3. The areas showing stability or improvement were as follows.

Protected area design: Slightly improved, from 64.44% to 68.89%.

Grouping of questions and elements of METT3

To analyze the questions by category, it was found that the grouped items (6) had acceptable Cronbach's alpha (>0.80) and McDonald's w (>0.90) values. Higher mean values were recorded in 2017, in comparison to 2024; see Tables 10 and 11.

Table 10. Characterization of the values obtained after grouping the questions and analyzing them by category.

Category	Application	Median	Standard Deviation	Median	IQR	Shapiro–Wilk W	Shapiro–Wilk *p*
Context	2017	2.87	0.35	3.00	0.00	0.41	0.001
	2024	2.73	0.46	3.00	0.50	0.56	0.001
Planning	2017	9.80	4.80	10.00	4.00	0.93	0.285
	2024	7.73	2.79	7.00	4.50	0.94	0.345
Inputs	2017	11.20	6.86	12.00	9.50	0.96	0.753
	2024	6.13	3.36	6.00	6.00	0.89	0.069
Processes	2017	18.53	11.38	17.00	17.00	0.96	0.665
	2024	10.00	6.20	8.00	9.00	0.89	0.064
Outcomes	2017	5.13	2.75	5.00	3.50	0.92	0.179
	2024	2.27	2.46	2.00	4.50	0.81	0.004

Table 11. Mann–Whitney U-test results comparing questionnaire responses between 2017 and 2024 for each METT3 category.

Category	Mann–Whitney U	*p*	Effect Size *	Bayes Factor
Context	97.50	0.386	0.13	0.47
Planning	87.50	0.305	0.22	0.75
Inputs	59.00	0.028	0.48	3.62
Processes	60.50	0.032	0.46	3.50
Outcomes	50.00	0.009	0.56	8.02
Outputs	73.50	0.098	0.56	1.02

* Biserial correlation of ranks.

Statistically significant differences were found in the following variables: Inputs, Processes, and Outcomes. The effect size (ES) of these three variables indicates a medium effect in all three cases: (a) Inputs, TE = 0.48; (b) Processes, TE = 0.46; and (c) Outcomes, TE = 0.56. The Bayes factor verified the above results as, in all three cases, it indicated moderate/medium evidence [48] in favor of the hypothesis that there exist differences between the 2017 and 2024 scores: (a) Inputs, Bayes = 3.62; (b) Processes, Bayes = 3.50; and (c) Outcomes, Bayes = 8.02 (Figure 3).

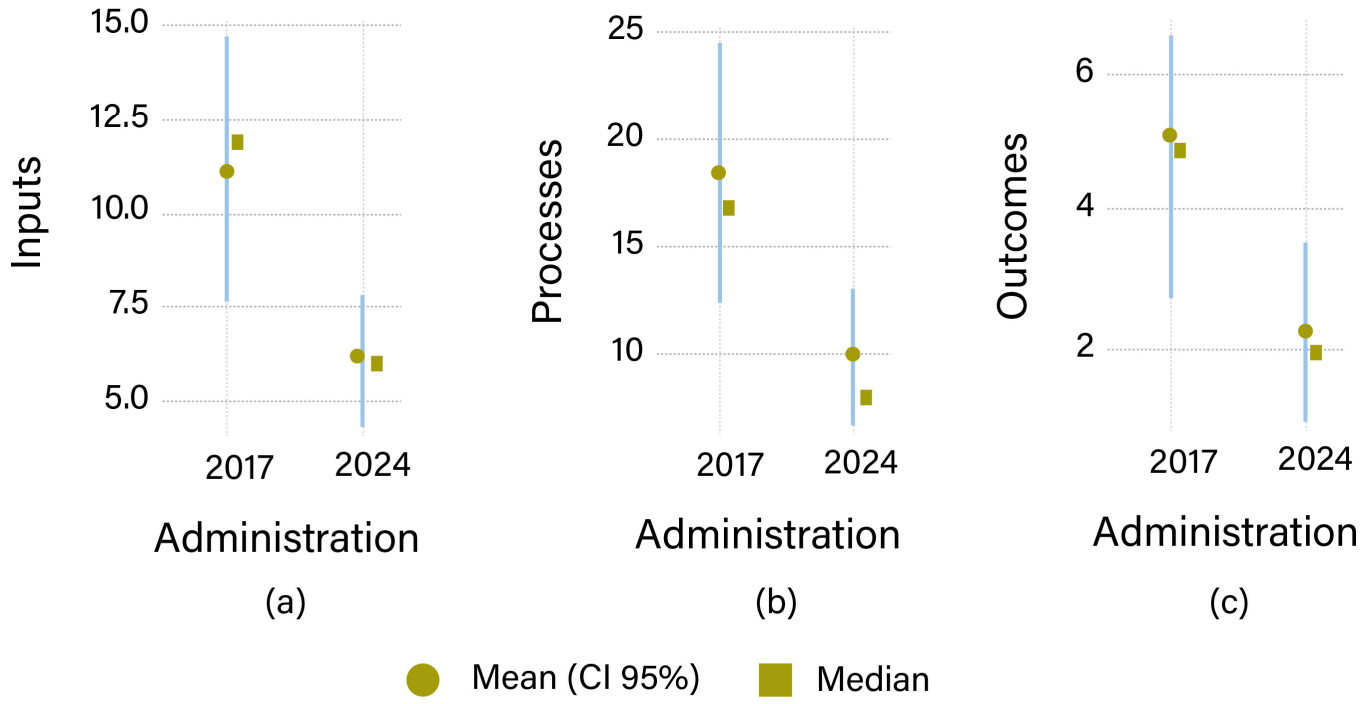

Figure 3. Graphical representation of statistically significant differences between 2017 and 2024 questionnaires for each METT3 category. (**a**) Inputs, (**b**) Processes, (**c**) Outcomes.

4. Discussion

4.1. Integration of Art. 3 Statutory Framework of the UNESCO MAB Programme into the CBR Management Program

The management program for the El Cielo Biosphere Reserve (CBR), approved in 2013, is largely in line with the statutory framework of the UNESCO MAB Programme, as it sets clear objectives for the conservation of biodiversity in this protected natural area.

The management program is a comprehensive document, but does not respond to current conservation challenges; that is, the components and actions of the subprograms do not directly incorporate the objectives of the 2016–2025 statutory framework. The implementation of conservation and development objectives poses significant challenges in the MAB-UNESCO model, but few cases have been demonstrated to meet all of the criteria of the model [10–12]. This is consistent with the findings of Dudley et al. [19,20], who found that international designations are not associated with successful management; this is because their membership in MAB-UNESCO is not binding, which remains the responsibility of the nation, and MAB-UNESCO also does not have the resources to conduct on-site assessments of each site included in the program.

Almost 40 years have passed since the date of the CBR decree. During this time, there have been eight state governments, each of which has remained in office for 6 years; there have been 13 municipal presidents for each of the four municipalities that have sites in the CBR; and, due to the fact that their term of authority is 3 years, 52 authorities have passed through the four municipalities. The constant change of authorities in the four municipalities has hindered effective and equitable participatory planning with the support of the local government, the national government, and the private sector, as established in the current MAB-UNESCO Strategy 2015–2025 and the Lima Action Plan (LAP) 2016–2025, according to Coetzer et al. [4,5,11].

According to Van Cuong et al. [9], the establishment of management systems for stakeholder engagement and governance structures is critical to the success of CBR, rather than understanding the concept of CBR stakeholders, as stated by Barraclough et al. [7]. In this line, Van Cuong et al. [9] found that the lack of resources available to BRs is a major factor leading to their failure and lack of continuity in their processes.

Resource scarcity has proven to be a major challenge for MAB implementation in developing countries, and it has been noted that establishing management systems for stakeholder engagement and governance structures is critical to the success of the CBR, even more so than understanding the concept of stakeholders in the CBR. According to Reed (2016) [8], the purpose, functions, and benefits of biosphere reserves are still not fully understood by scientists, policy makers, and local communities.

The lack of updating of the management program, even though the CBR is part of the network of reserves of the MAB-UNESCO program, coincides with previous studies [10–12] reporting that there are few cases demonstrating successful BR implementation and compliance with all of the criteria. Although the CBR governance model is based on the UNESCO-MAB *Statutory Framework and Technical Guidelines* [1,8,9], it has significant opportunities for improvement; for example, the failure to submit a status assessment for the CBR, as indicated in Article 9 of the UNESCO-MAB statutory framework, constitutes a breach of its obligations as part of the World Network of Biosphere Reserves. Furthermore, the lack of up-to-date information means that UNESCO and the international community do not have up-to-date information on the conservation status of biodiversity, ecosystems, and ecosystem services in the CBR. Failure to meet MAB obligations could jeopardize the international support that the CBR receives, including funding, technical assistance, and recognition as part of the World Network of Biosphere Reserves.

4.2. Linkage of the CBR Management Program (25) with the 2030 Agenda for Sustainable Development

The Sustainable Development Goals (SDGs) of the 2030 Agenda were adopted on 25 September 2015, which include 17 SDGs that came into force on 1 January 2016. The CBR management program is from 2013, so these goals are not directly considered. The conducted analysis did not demonstrate any explicit and direct links between the CBR management program and the Sustainable Development Goals (SDGs) of the 2030 Agenda. Even though the reserve is located within an international framework that promotes sustainability, its management plan does not clearly integrate SDG indicators and targets.

For example, a human analysis of the concepts associated with the SDGs of the 2030 Agenda revealed a lack of direct links to the Aichi Targets, the Convention on Biological Diversity (CBD), the ecosystem approach, ecosystem services, ecosystem-based management, and education for sustainable development (ESD).

The absence of a holistic approach that considers social, economic, and environmental dimensions limits the ability of the CBR to effectively contribute to the achievement of the SDGs. For example, no specific actions were identified to reduce poverty, ensure food security, promote gender equality, or combat climate change, all of which are central goals of the 2030 Agenda.

In addition, the review of the management program did not reveal the integration of key concepts related to sustainability, such as ecosystem services, ecosystem-based management, or education for sustainable development. This lack of focus prevents leveraging of the opportunities offered by the 2030 Agenda to strengthen the management of the protected area, which would generate benefits for both the environment and local communities.

4.3. Evaluation of Effectiveness

There is a need to evaluate the management effectiveness of biosphere reserves included in the MAB-UNESCO program, in order to understand the associated governance processes in specific contexts and identify both strengths and weaknesses [16]. The results of the 2017 and 2024 METT3 assessments of the CBR's management efficiency showed consistent numerical trends of deterioration. The associated challenges range from financial and capacity constraints to poor management and insufficient understanding of its importance as a UNESCO biosphere reserve, as has been previously noted by Barraclough et al. [7].

Context: Even in the legal status, where the highest ratings were obtained, there was a decline in the rating from 95.56% to 91.11%.

Planning: Planning in the CBR is perceived as inadequate, as evidenced by the "0" ratings given in 2017 and 2024 to the category of planning for monitoring and evaluation of land and water use, which indicates a critical deficiency that reflects non-compliance with planned obligations, as well as lack of progress towards sustainable development or conservation goals. Furthermore, the perceived effectiveness of conservation rules (regulations) decreased by nearly 50%, from 64.44% in 2017 to 31.11% in 2024.

Inputs: Resources for management of the CBR are far from adequate, and the lack of governmental financial support is a persistent problem, as confirmed by studies such as those of Dudley et al. (2004; 2007) and reflected in the 2017 and 2024 assessment statistics, which demonstrated a dramatic decline in the areas of "current budget" and "budget security" from 42.22% to 8.89% and from 35.56% to 6.67%, respectively.

This decline underscores how inadequate financial resources have degraded the ability of protected areas to sustain their operations and conservation projects, highlighting the need to explore new sources of funding, including collaboration with the private sector, as has been noted previously [1,14]. The lack of available resources for BRs is a major factor leading to their failure and lack of continuity in the process, as stated by Van Cuong et al. [9]. Stoll-Kleemann and O'Riordan (2018) [14] found that a lack of resources has proven to be a major issue in the implementation of MAB-UNESCO areas in developing countries. Furthermore, Barraclough et al. [7] noted that reserves in developed countries are unable to meet the requirements due to a lack of staff and training.

The assessment also revealed a decline in the "personnel" category, from 53.33% to 31.11%, which suggests potential problems with staff retention, training or, possibly, reductions in the workforce and "resource management" categories, indicating increasing problems in maintaining the staff required for CBR conservation and shortcomings in the effective management of natural and financial resources [14]. Governance and community involvement are critical to the success of the CBR.

Processes: The adequacy of management processes is perceived as insufficient, as reflected in the lack of maintenance of equipment, which decreased from 37.78% to 2.22%, thus hindering operations in the CBR, and which may be related to the lack of financial resources for CBR management. The lack of understanding of the importance of the UNESCO MAB designation is reflected in the notable decrease in "education and awareness", from 48.89% to 4.44%. This suggests a disconnect in communication about the importance of conservation and may reflect a lack of effort to educate and sensitize local communities and other stakeholders regarding the importance and benefits of the property, potentially limiting their participation and support [8].

The decrease in the "local communities" category of management, from 51.11% to 13.33%, reflects the need to improve governance strategies and more actively involve local communities in decision making to ensure that their interests and knowledge are considered in the planning and implementation of conservation activities [7,13]. Barraclough et al. (2023) [7] highlighted the importance of community involvement in the management of biosphere reserves, but also mentioned the widespread absence of key stakeholders in development and conservation discussions, as reflected in the disengagement with tour operators, which decreased from 51.11% to 11.11%.

A lack of local partnerships and the absence of key stakeholders in socio-economic development and biodiversity conservation discussions have been identified as some of the reasons why the objectives of MAB-UNESCO reserves are not being met [3,4].

Outputs: The results of management actions, as reflected in outputs and services, indicate that visitor facilities are not considered to be the most appropriate, as evidenced by the obtained ratings, which decreased from 57.78% to 51.11%; and the existence of work in progress, as the periodic work plan has decreased from 15.56% to 3.78%.

Outcomes: The effects of management on the achievement of objectives indicated that the overall protection systems in the CBR have decreased from 35.56% to 11.11%. The

economic benefits to local communities—such as income, employment, and payment for environmental services—are also perceived to have decreased, from 60.00% to 35.56%. As a result, the status of the important values of the protected area is also perceived to have deteriorated, from 75.56% in 2017 to 28.89% in 2024, compared to when it was first designated.

The evaluation elements from 2017 to 2024, by participant group, show that "community" and "government" presented the strongest decreases overall. For "community," the steepest declines were seen in the "Process" dimension, which may be a sign of deficiencies in the way the CBR is managed. As for "government," relative stability was observed in the "Context" and "Inputs" dimensions, while declines in "Process" and "Outputs" were observed. This analysis suggests that it may be useful to conduct a more in-depth evaluation of the policies, strategies, and methods used to engage these groups and to improve the areas where declines are observed, particularly in the Process and Outcome criteria.

The analysis revealed a clear correspondence between the concerns raised by the experts and the quantitative results obtained through the 2017 and 2024 assessments. These challenges highlight the need for a comprehensive review and implementation of improved strategies that address funding and capacity, as well as education and community engagement.

It is important to acknowledge the limitations of the study, as it is a case study that does not allow for generalization of the obtained results. Although the METT3 tool has been used globally, it is considered a rapid assessment that requires an evaluation of its implementation; however, it helps to fill a gap caused by a lack of studies at the local level that identify problems and their solutions in different contexts.

The results of this work have been presented to government authorities and other international bodies. As a result, an international diploma course on protected areas and development has been designed for members of the state government, municipalities, and communities. In addition, we are studying another protected natural area to design adaptive management systems and are participating in the elaboration process of the new CBR management program. We are also working to apply the METT version 4 tool in the CBR in 2025, as well as implementing this tool in the seven state protected natural areas of Tamaulipas.

5. Conclusions

The conducted analysis revealed that the designation of a protected natural area (PNA) is merely the beginning of a long-term commitment to go beyond being a "paper park." The analysis of the management plan for the El Cielo Biosphere Reserve showed that it is a static document that has not been updated in accordance with the statutory framework of the UNESCO MAB Programme, nor aligned with the Sustainable Development Goals of the 2030 Agenda.

The implications of this are evident in the evaluations conducted using the METT3 tool in 2017 and 2024, which revealed the perceptions of researchers, community members, and public entities regarding the management of the biosphere reserve. The results demonstrated a decline in effectiveness scores over time (from 2017 to 2024), which could be attributed to a combination of factors, including insufficient coordination between the reserve's management authority, government entities, local communities, and non-governmental organizations.

The implementation of a mixed-methods exploratory study design, which contrasted the instruments through qualitative and quantitative analyses, was very important, as it allowed us to obtain a perspective on the "paper" document (which is over ten years old) and of the research conducted over time, which allowed for elaboration of how the management of the biosphere reserve has deteriorated.

The results of this work highlight that the stakeholders involved in the management of the biosphere reserve have not understood the purpose, activities, and potential benefits of the site, and that the capacities of the administrative authority have been overwhelmed.

Furthermore, they underscore the urgency of reviewing and improving management and financing strategies within the reserve. The deterioration of the management effectiveness of the reserve has led to a significant failure to fulfill the conservation, development, and logistical support functions established by the UNESCO MAB Programme, affecting not only local biodiversity but also the sustainable development of associated communities.

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