

Original article



Strategic management model for agroecological transition in biosphere reserves

Modelo de gestión estratégica para la transición agroecológica en reservas de la biosfera

Modelo de gestão estratégica para a transição agroecológica em reservas da biosfera

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ABSTRACT

Biosphere reserves face crises of institutional fragmentation and disconnection between regulatory frameworks and local practices that threaten their conservation capacity. This research aimed to design a strategic management model based on organizational change theory for biosphere reserves, integrating agroecological principles and strategic foresight. The study was developed using a mixed approach (quantitative-qualitative), non-experimental cross-sectional design and Delphi method for

validation. The research was structured in three phases: bio-socioeconomic characterization and participatory diagnosis with 23 communities; model design based on the integration of Lewin's change theory, Kotter's 8 phases and Galbraith's Star model; and theoretical-practical validation through contrast with international frameworks and pilot application in three communities. The result was a model structured in three interconnected subsystems (diagnosis and social mobilization; progressive management and implementation; prospective organizational architecture), articulated through a cross-cutting phase of control and feedback. The model incorporates innovative mechanisms such as territorial stewardship contracts, community co-management platforms and Dinamica EGO modeling for climate scenarios. Expected results, validated with 15 specialists (concordance index 0,82), include 40% increase in climate resilience through successional agroforestry systems, reduction of project approval times from 90 to 30 days through coordination nodes, and 35% improvement in community participation. The model contributes to overcoming institutional fragmentation and promoting agroecological transitions through adaptive governance, constituting a scalable reference for biosphere reserves in Cuba and Latin America.

Keywords: strategic management; organizational change; biosphere reserves; agroecology; foresight; adaptive governance; Dinamica EGO modeling.

RESUMEN

Las reservas de biosfera enfrentan crisis de fragmentación institucional y desconexión entre marcos normativos y prácticas locales que amenazan su capacidad de conservación. Esta investigación tuvo como objetivo diseñar un modelo de gestión estratégica basado en teoría del cambio organizacional para reservas de biosfera, integrando principios agroecológicos y prospectiva estratégica. El estudio se desarrolló mediante enfoque mixto (cuantitativo-cualitativo), diseño no experimental transeccional y método Delphi para validación. La investigación se estructuró en tres fases: caracterización bio-socioeconómica y diagnóstico participativo con 23 comunidades; diseño del modelo fundamentado en la integración de la teoría del cambio de Lewin, las 8 fases de Kotter y el modelo Star de Galbraith; y validación teórico-práctica mediante contraste con marcos internacionales y aplicación piloto en tres comunidades. Como resultado se obtuvo un modelo estructurado en tres subsistemas interconectados (diagnóstico y movilización social; gestión e implementación progresiva; arquitectura organizacional prospectiva), articulados mediante una fase transversal de control y retroalimentación. El modelo incorpora mecanismos innovadores como

contratos de custodia territorial, plataformas de coestión comunitaria y modelización Dinamica EGO para escenarios climáticos. Los resultados esperados, validados con 15 especialistas (índice de concordancia 0,82), incluyen el aumento del 40% en resiliencia climática mediante sistemas agroforestales sucesionales, reducción de tiempos de aprobación de proyectos de 90 a 30 días mediante nodos de coordinación, y mejora del 35% en participación comunitaria. El modelo contribuye a superar la fragmentación institucional y promover transiciones agroecológicas mediante gobernanza adaptativa, constituyendo un referente escalable para reservas de biosfera de Cuba y América Latina.

Palabras clave: gestión estratégica; cambio organizacional; reservas de biosfera; agroecología; prospectiva; gobernanza adaptativa; modelización Dinamica EGO.

RESUMO

As reservas da biosfera enfrentam uma crise de fragmentação institucional e uma desconexão entre os marcos regulatórios e as práticas locais, o que ameaça sua capacidade de conservação. Esta pesquisa teve como objetivo desenvolver um modelo de gestão estratégica para reservas da biosfera baseado na teoria da mudança organizacional, integrando princípios agroecológicos e prospecção estratégica. O estudo foi conduzido utilizando uma abordagem mista (quantitativa-qualitativa), um delineamento transversal não experimental e o método Delphi para validação. A pesquisa foi estruturada em três fases: caracterização bio-socioeconômica e diagnóstico participativo com 23 comunidades; desenvolvimento do modelo baseado na integração da teoria da mudança de Lewin, das oito fases de Kotter e do modelo Star de Galbraith; e validação teórico-prática por meio da comparação com marcos internacionais e aplicação piloto em três comunidades. O resultado foi um modelo estruturado em torno de três subsistemas interconectados (diagnóstico e mobilização social; gestão e implementação progressiva; e arquitetura organizacional prospectiva), articulados por meio de uma fase transversal de controle e feedback. O modelo incorpora mecanismos inovadores, como contratos de gestão territorial, plataformas de cogestão comunitária e modelagem EGO Dynamic para cenários climáticos. Os resultados esperados, validados com 15 especialistas (índice de concordância de 0,82), incluem um aumento de 40% na resiliência climática por meio de sistemas agroflorestais sucessionais, uma redução no tempo de aprovação de projetos de 90 para 30 dias por meio de nós de coordenação e uma melhoria de 35% na participação da comunidade. O modelo contribui para superar a fragmentação institucional e promover transições agroecológicas por meio

da governança adaptativa, constituindo um modelo de referência escalável para reservas da biosfera em Cuba e na América Latina.

Palavras-chave: gestão estratégica; mudança organizacional; reservas da biosfera; agroecologia; prospectiva; governança adaptativa; modelagem Dinamica EGO.

INTRODUCTION

Biosphere reserves face critical challenges in the 21st century, where institutional fragmentation and a disconnect between regulatory frameworks and local practices threaten their capacity to conserve biodiversity in the face of pressures such as climate change. According to the UNESCO MAB Programme report (2022), the global network of biosphere reserves comprises 727 sites in 131 countries, representing 5% of the Earth's land surface and home to more than 250 million people. However, recent studies document that many of these reserves suffer from governance problems, institutional fragmentation, and weak community participation, which limit their management effectiveness. This situation is reflected in the drastic reduction in management effectiveness in territories under high human pressure, forcing institutions to resort to innovative governance mechanisms due to the inadequacy of traditional sectoral approaches.

Recent meta-analyses on protected area governance demonstrate that adaptive management approaches significantly increase ecological connectivity and socio-institutional resilience in 18 of 20 reserves evaluated (Lin et al., 2021; Schultz et al., 2011). Specifically in Latin American contexts, multi-stakeholder co-management platforms have been shown to improve coordination between organizational scales, reducing competition conflicts between state institutions and non-governmental organizations by up to 45% (Catacora Vargas et al., 2022). These experiences validate that the integration of traditional knowledge with scientific knowledge, mediated by planned organizational change processes, creates the conditions for the transition to resilient agroecological systems.

In Cuba, biosphere reserves have been promoted through the UNESCO MAB Programme since the 1980s, demonstrating the viability of participatory conservation and sustainable development. However, these initiatives lack systemic integration that articulates territorial diagnosis, progressive implementation, and a prospective organizational architecture, requiring a comprehensive model that

overcomes the institutional fragmentation documented in recent studies of participatory governance (Oladeji et al., 2022). Successful experiences in other Ibero-American regions highlight the importance of land stewardship contracts and climate scenario modeling as effective tools for adaptive governance (Kane, 2018; Pinto et al., 2025).

The application of organizational change theory in conservation contexts has shown promising results. Lewin's (1947) theory, based on the unfreeze-move-refreeze stages, provides the framework for the diagnostic and social mobilization phase. Cummings et al. (2016) reinterpret this classic model from a contemporary perspective, analyzing its evolution and relevance in change management. In turn, Kotter's (1996) eight phases offer a validated sequential process for implementing institutional transformations (first creating urgency, forming coalitions, and communicating the vision; then empowering action, generating short-term wins, consolidating gains, and anchoring changes in the organizational culture).

This model has been empirically validated in recent sustainability studies, such as that of Mouazen et al. (2024), who analyzed the role of transformational leadership in the implementation of the Kotter (1996) model in 385 companies, demonstrating that the alignment between leadership style and phases of change significantly enhances results. Meanwhile, Galbraith's (1977) Star model, widely recognized in the organizational design literature, allows for structuring a prospective organizational architecture by aligning five interdependent elements: strategy, structure, processes, people, and rewards. Recent research has applied this framework in the context of sustainability and organizational change, demonstrating its usefulness in aligning management with sustainable development goals.

This proposal aligns with the Kunming-Montreal Global Biodiversity Framework (CBD, 2022), which prioritizes synergies between traditional and scientific knowledge, sustainable livelihoods, and adaptive governance. The objective of this research was to design a strategic management model based on organizational change theory that integrates agroecological principles and strategic foresight for biosphere reserves, contributing to socio-ecological sustainability and local food sovereignty.

MATERIALS AND METHODS

The research was conducted using a mixed-methods approach (quantitative-qualitative), through a descriptive-propositive study of the biosphere reserve (2023-2024). The methodological design was based on the triangulation of sources (documents, interviews, workshops, Delphi) and methods (analytical-descriptive and participatory) to ensure internal validity and reliability (Hernández Sampieri et al., 2014).

Phase 1: Bio-socioeconomic characterization and participatory strategic diagnosis

the Scopus and Web of databases. Science, SciELO and institutional repositories (2020-2024), using controlled descriptors: " biosphere reserves governance ", " organizational change ", " agroecological transition ", " adaptive management," " strategic" " foresight ". Inclusion criteria were applied: (a) publications 2019-2024, (b) Spanish/English language, (c) JCR impact factor ≥ 1.5 .

In parallel, 68 documents were analyzed, including technical reports from the UNESCO MAB Programme, reserve management plans, and indexed scientific publications, selected through purposive sampling based on thematic relevance. The documents were analyzed using qualitative content analysis, employing the approach of Graneheim and Lundman (2004) to guarantee the reliability and validity of the documentary analysis.

The study population comprised 287 key stakeholders identified in the reserve's area of influence, including agroforestry producers (45%), institutional representatives (30%), community leaders (15%), and academics (10%). A non-probability sampling method was used, selecting 125 participants who met defined inclusion criteria: a minimum of five years' experience in the territory, direct knowledge of the production systems, and willingness to participate in the research process.

Primary data collection techniques

Semi-structured interviews: Thirty-five interviews were conducted with key informants: institutional managers (n=8), community leaders (n=15), and agroforestry producers (n=12). Participants were selected based on their territorial experience (minimum 5 years) and direct knowledge of production systems. The interviews were structured around four dimensions: (a) institutional diagnosis and fragmentation, (b) local agroecological practices, (c) perceptions of adaptive governance, and (d) climate outlook and scenarios. The interview guide was validated by three environmental

management experts (Content Validity Coefficient: CVI=0.88) and pilot-tested (n=3) before final implementation.

The interviews were conducted between January and March 2023, with an average duration of 60 minutes. Informed consent was obtained from all participants, and confidentiality was ensured through alphanumeric coding. The interviews were audio-recorded (with permission) and transcribed verbatim.

Participatory SWOT diagnostic workshops: Twelve workshops were conducted with 125 participants from 23 communities (producers, technicians, institutional representatives), selected based on their involvement in agroforestry systems and their availability to participate. Each workshop lasted six hours and was structured in three parts: (i) presentation of the biophysical context by the research team, (ii) focus groups identifying strengths, opportunities, weaknesses, and threats (expanded SWOT analysis), and (iii) collective construction of prioritization matrices using a weighted voting technique.

Workshop minutes with photographic records, signed attendance lists, and consensus matrices were prepared. The information was systematized using thematic content analysis (Hsieh & Shannon, 2005).

Governance network analysis: Social network analysis techniques were applied to identify the density of connections between institutional and community actors, calculating centrality and density indices using UCINET software.

Phase 2: Practical application of the model - Operational validation pilot case

To ensure the understanding and replicability of the model, a pilot application was implemented in three representative communities of the reserve (n=45 producers), following the sequence of the three subsystems and the control phase:

Application of Subsystem I (Diagnosis and Mobilization): An organizational defrosting workshop (adapted from Lewin (1947), according to Cummings et al. (2016) was conducted in the "El Rosario" community with 18 producers and 5 institutional representatives. The technique applied was the Participatory Social Network Analysis Matrix, where the actors visually mapped (using colored cards) their coordination relationships. Central actors (red) were identified: 3 state

institutions with a centrality index of 0.78; peripheral actors (blue) were identified: 12 producers with a density index of 0.32; and connection gaps (white) were identified: 8 spaces without articulation between actors.

This visualization allowed the development of pilot Territorial Custody Contracts, signed by 15 producers and 2 institutional representatives, establishing specific commitments to the conservation of 25 hectares of agroforestry systems.

Application of Subsystem II (Management and Implementation): The initial phases of Kotter's organizational change model were implemented, following the empirical adaptations validated by Mouazen et al. (2024), who demonstrate the effectiveness of this model in sustainability contexts through an empirical study with 385 companies. The following actions were carried out during the period March-June 2023:

- Phase 1 (Creating urgency): Data on soil loss (15% annually) was presented through participatory mapping with community GPS, generating collective awareness among the 45 participants of the pilot.
- Phase 2 (Coalition Formation): The Local Agroecological Management Board (MESAGRO) was established, made up of 7 leaders (4 producers, 3 technicians), with bi-weekly meeting protocols.
- Phase 3 (Vision Creation): 15 SMART indicators were defined participatively using the inverted problem tree technique, highlighting the goal: 'Restore 10 hectares with successional agroforestry systems by December 2024'.

Application of Subsystem III (Prospective Architecture): The Dinamica EGO v.5.1 software (Remote Sensing Center, UFMG) was used to model land use change scenarios (2023-2050). The parameters entered were: static variables (topography, soil types, priority biological corridors) and dynamic variables (agricultural expansion rate of 12% per year, conservation policies, adoption of agroforestry).

Three scenarios were generated: (1) Trend: no intervention (35% loss of forest cover by 2050); (2) Intermediate: partial implementation of the model (15% loss, stabilization of corridors); (3) Optimal: full implementation with adaptive governance (20% recovery of cover).

Application of Phase IV (Control and Feedback): The Participatory Adaptive Monitoring System (SIMAP) was established, with quarterly evaluation through: (a) Governance Indicators Matrix (score 1-5 on coordination, participation, resilience criteria), and (b) Learning Wheel: feedback workshops where actors adjusted strategies every 3 months.

Data triangulation: The results of the pilot (adoption of practices, institutional response times, changes in vegetation cover) were compared with structured survey data from the 45 participants (pre/post intervention), documentary analysis of the minutes of the 6 MESAGRO meetings, and satellite images (Sentinel-2) of cover change in the 10 pilot hectares.

Phase 3: Data analysis, model construction and validation

Qualitative data were processed using grounded theory, with Atlas.ti 9 software for axial and selective coding. Quantitative data were processed with SPSS 25, applying descriptive and inferential statistical analysis (chi-square, Pearson correlation).

The model was constructed using a theoretical integration method, combining three complementary approaches. First, Lewin's (1947) Theory of Change, reinterpreted by Cummings et al. (2016) in the journal *Human Relations*, underpins Subsystem I (Diagnosis and Social Mobilization) by providing the conceptual framework for the organizational unfreezing, movement, and refreezing stages. Second, Kotter's (1996) 8-Phase Model, with empirical adaptations validated by Mouazen et al. (2024) in the journal *Sustainability*, supports Subsystem II (Management and Progressive Implementation), demonstrating its effectiveness in sustainability contexts through an empirical study with 385 companies. Third, Galbraith's (1977) Star model, widely recognized in the organizational design literature and currently in force through indexed publications such as those of Galbraith (2014), structures Subsystem III (Prospective Organizational Architecture), by aligning five interdependent elements: strategy, structure, processes, people, and rewards.

Phase IV of Control and Feedback was explicitly designed, articulating the three subsystems through participatory evaluation mechanisms and adaptive adjustments, following the principles of adaptive governance documented by Folke et al. (2005).

Subsequently, the Delphi method was applied with two rounds of consultation with 15 specialists (5 in environmental management, 5 in agroecology, and 5 in organizational change), selected based on criteria of international experience (minimum 10 years) and indexed publications on the topic. The

established validation criteria were: Kendall's coefficient of concordance ≥ 0.80 (considered acceptable), index of theoretical relevance, and practical applicability.

Quantitative projections (2025-2030) were calculated using scenario analysis: (a) conservative scenario (gradual adoption), (b) moderate scenario (accelerated adoption), and (c) optimistic scenario (massive adoption). The moderate scenario was selected as a viable target, with 95% confidence intervals.

Theoretical validation was carried out by contrasting with: UNESCO MAB Programme (operating criteria), Kunming-Montreal Global Biodiversity Framework (Goals 1, 2, 3 and 10) and Sustainable Development Goals (SDGs 2, 13, 15).

RESULTS AND DISCUSSION

Diagnostic characterization of the territorial management system

The comprehensive diagnosis revealed a complex scenario characterized by significant biological richness and critical institutional fragmentation. Twelve vegetation types and 143 endemic species were identified. Traditional agroforestry systems showed a complex structure integrating *Coffea Arabica* and *Theobroma cacao* with *Cedrela odorata* and *Swietenia macrophylla*.

Land-use change analysis using satellite imagery (2019-2023) quantified a fragmentation rate of 12% per year in priority biological corridors, associated with the expansion of intensive crops. The institutional assessment identified 7 government agencies and 23 non-governmental organizations with overlapping responsibilities.

The governance network analysis revealed excessive centrality in state institutions (centrality index = 0.78) and a low density of connections with community actors (density index = 0.32), confirming the findings of Schultz et al. (2011) and Catacora Vargas et al. (2022) on institutional fragmentation in Caribbean reserves. These data highlight the need for formal coordination mechanisms that overcome sectoral segmentation.

Applying Lewin's theory of change revealed that 68% of producers maintain traditional agroecological practices, although only 25% apply them systematically. Participatory workshops showed that the main barrier to the agroecological transition is the lack of access to differentiated markets (72% of

participants), followed by insufficient specialized technical assistance (64%). These results are consistent with recent studies on community participation in conservation (Oladeji et al., 2022).

Design of the strategic management model

The key outcome was a management model structured around three interconnected subsystems, linked by a cross-cutting phase of control and feedback. Implementation of the model requires the following prerequisites: (a) the existence of a regulatory framework that recognizes shared governance in protected areas; (b) the availability of up-to-date bio-socioeconomic information for the territory; (c) the formation of an initial coalition of stakeholders committed to the agroecological transition; (d) access to prospective modeling tools and the technical capacity to manage them; and (e) the allocation of financial resources for the organizational de-freezing phase and incentive mechanisms.

The model aims to overcome institutional fragmentation and the disconnect between regulatory frameworks and local practices in biosphere reserves through the systematic integration of three processes: participatory diagnosis and social mobilization (Subsystem I), the progressive management and implementation of the agroecological transition (Subsystem II), and the development of a forward-looking organizational architecture (Subsystem III), all supported by permanent mechanisms of control and adaptive feedback (Phase IV). Consequently, the model seeks to create the organizational, technical, and institutional conditions for biosphere reserves to transition toward resilient agroecological systems, articulating organizational scales and promoting effective community participation as the basis for adaptive governance.

The complete architecture of the model, illustrating the systemic integration of the three subsystems, the cross-cutting control phase, and the theoretical frameworks, is shown in Figure 1. The model integrates three interconnected subsystems: I: Diagnosis and Social Mobilization based on Lewin (1947); II: Management and Implementation based on Kotter's (1996) eight phases; and III: Prospective Architecture based on Galbraith's (1977) Star model. These are articulated through Phase IV of Control and Feedback (participatory evaluation and adaptive adjustments). The cross-cutting themes of Technological Foresight and Community Co-management run through all subsystems. The base demonstrates alignment with international frameworks (UNESCO MAB Programme, the Kunming-Montreal Global Biodiversity Framework, and the Sustainable Development Goals).



Figure 1. Architecture of the strategic management model for the agroecological transition in biosphere reserves

Source: Own elaboration

Subsystem I: Diagnosis and Social Mobilization

Based on Lewin's (1947) theory of change, reinterpreted by Cummings et al. (2016), in its 'organizational unfreezing' phase, this subsystem aims to raise awareness about the need for transformation and mobilize social actors.

It incorporates territorial custodianship contracts as an innovative mechanism. These agreements, documented in academic literature as an effective tool for the co-management of natural resources, formalize the relationship between communities and conservation institutions, establishing mutual commitments to sustainable management. Recent studies have evaluated their positive impact on biodiversity conservation, such as the analysis by Mora et al. (2018) in the Colombian Amazon, which

demonstrates the effectiveness of these agreements for the protection of threatened species and the improvement of local livelihoods.

Furthermore, the documented experience in the Alto Mayo Biosphere Reserve, Peru, where Conservation International has implemented more than 1,000 stewardship agreements reducing deforestation, has been analyzed in academic publications that validate this approach. In the Cuban context, these contracts are adapted to the legal framework of protected areas, recognizing producers as active custodians of biodiversity, following the principles of adaptive governance established by the UNESCO MAB Programme.

Subsystem II: Management and Progressive Implementation

Structured according to Kotter's 8-phase model of organizational change, with empirical adaptations validated by Mouazen et al. (2024) for agroecological transitions, this subsystem is developed as follows:

- Phase 1 (Create urgency): Based on data of annual soil loss (15% in areas of intensive agriculture), collective awareness is generated about the need for transformation.
- Phase 2 (Form coalition): The Local Agroecological Management Board (MESAGRO) is established, made up of 7 leaders (4 producers, 3 technicians), with bi-weekly meeting protocols and decision-making by consensus.
- Phase 3 (Create vision): Participatory definition of 15 SMART indicators, including the goal of restoring 10 hectares with successional agroforestry systems.

Phases 4-8 (Implementation and consolidation): Communication of change through community assemblies, elimination of bureaucratic obstacles (reduction of procedures), generation of short-term wins (successful harvests in pilot plots), consolidation of gains (scaling up to new communities) and anchoring in the culture (incorporation of agroecological practices in local regulations).

The implementation of successional agroforestry systems can increase climate resilience by 40%, coinciding with FAO (2022) projections, which identify the expansion of agroforestry as one of the three key pathways for green recovery and the building of inclusive, resilient and sustainable economies, with the potential to restore 1.5 billion hectares of degraded land and capture up to 1.5 GtCO₂e per year.

Subsystem III: Prospective Organizational Architecture

Galbraith's (1977) Star model, widely recognized in the organizational design literature, and updated by the author himself for contemporary contexts (Galbraith, 2014), this subsystem structures adaptive governance through five interdependent elements:

- Strategy: Conservation objectives linked to sustainable livelihoods, aligned with the Kunming-Montreal Global Biodiversity Framework (CBD, 2022), which prioritizes the integration of conservation with sustainable development and the participation of local communities.
- Structure: Intersectoral coordination nodes with action protocols that reduce project approval times from 90 to 30 days, validated in the pilot through MESAGRO.
- Processes: Horizontal and vertical information flows integrating traditional and scientific knowledge, through permanent dialogue platforms, following the principles of adaptive governance documented by Folke et al. (2005).
- People: Capacity building in technological forecasting, with 45 producers and technicians trained in the management of agroforestry systems and bio-inputs.
- Rewards: Incentive systems through Participatory Guarantee Systems, validating agroecological production for access to differentiated markets.

The integration of technological foresight through Dinamica EGO modeling allowed the projection of three climate scenarios (2030-2050).

Phase IV: Control and Feedback (Cross-cutting)

This phase closes the management cycle by:

- Participatory evaluation: Joint monitoring of compliance with SMART indicators through the SIMAP system (Quarterly sessions with a score of 1-5 in governance).
- Adaptive adjustments: Course correction mechanisms based on adaptive governance principles (Folke et al., 2005).

Organizational learning: Iterative cycles that provide feedback to Subsystem I

Model validation

The Delphi method validation yielded consistent results after two rounds of consultation. Fifteen specialists participated (5 in environmental management, 5 in agroecology, and 5 in organizational change), selected based on international experience, indexed publications on the topic, and participation in adaptive governance projects in protected areas of Latin America during the period 2019-2024. Inclusion criteria required: (a) a minimum of 10 years of experience in the management of biosphere reserves or protected areas; (b) at least three scientific publications in JCR journals ≥ 1.5 on environmental governance, agroecology, or organizational change; (c) direct participation in co-management processes or multi-stakeholder platforms in biosphere reserves of Latin America; and (d) availability to participate in both rounds of the Delphi method. The results obtained were:

- Concordance index: 0.82 (theoretical relevance)
- Applicability index: 0.78 (practical feasibility)

Comparison with international experiences revealed a high degree of agreement with adaptive governance mechanisms implemented in the El Vizcaíno Biosphere Reserve, Mexico, where the multi-stakeholder platform (Advisory Council) has successfully developed the capacity to influence government institutions through collective lobbying, securing public funding and participating in various management activities, despite limitations stemming from the lack of a clearly defined executive mandate (Brenner, 2019). Similarly, studies on multi-stakeholder platforms in Mexican biosphere reserves have demonstrated that advisory councils are fundamental mechanisms for the participation of local actors in decision-making, although their effectiveness critically depends on favorable socioeconomic conditions, efficient internal organization, and institutional influence (Brenner & De La Vega Leinert, 2014; Brenner & Job, 2012). The proposed model incorporates significant innovations by explicitly integrating technological foresight (EGO Dynamics) and territorial custody contracts as cross-cutting axes, overcoming the institutional fragmentation documented in other Latin American reserves through formal mechanisms of intersectoral coordination.

Theoretical validation demonstrated alignment with: MAB-UNESCO Programme (criteria for conservation, development and logistical support function); Kunming-Montreal Global Biodiversity Framework (Goals 1, 2, 3 and 10); and Sustainable Development Goals (SDGs 2, 13 and 15).

Model effectiveness

The effectiveness of the model lies in its ability to articulate organizational scales through formal coordination mechanisms, overcoming the limitations of traditional sectoral approaches documented in recent studies on participatory governance in protected areas (Oladeji et al., 2022). The integration of foresight represents a significant contribution, considering that the systematic application of adaptive and foresight management approaches in biosphere reserves is still limited; previous studies have documented that less than 30% of the reserves in the World Network apply these approaches in a comprehensive manner.

The results demonstrate that the model comprehensively addresses the problem of institutional fragmentation, establishing a solid foundation for the agroecological transition through innovative financial mechanisms and structured community participation processes. The articulation between the participatory diagnosis (Cummings et al., 2016; Lewin, 1947), phased management (Kotter, 1996; Mouazen et al., 2024) and prospective organizational architecture (Galbraith, 1977, 2014) constitute a substantial contribution to the field of protected area management.

However, effective implementation will face challenges: (a) availability of up-to-date secondary information, (b) resistance to change in established institutional structures, and (c) the need for specialized technical capabilities in foresight and modeling. These limitations were mitigated through methodological triangulation, but require monitoring during the implementation phase.

The study made it possible to design a strategic management model that coherently integrates the theory of organizational change with agroecological principles and a prospective approach, offering a structural response to problems of institutional fragmentation and disconnection of local practices in biosphere reserves.

The main contribution lies in offering an operational framework for the transition to adaptive management systems that articulate organizational scales and promote effective community participation. The design of land stewardship contracts, co-management platforms, and a SMART indicator system represent concrete tools for overcoming documented institutional fragmentation.

The model is envisioned as a platform for institutional innovation that reconciles biodiversity conservation with inclusive local development, particularly through youth empowerment and the

valorization of traditional knowledge. A phased implementation process is recommended, beginning with pilot projects that demonstrate tangible benefits of the agroecological transition.

Research lines remain open related to: (a) economic quantification of benefits of successional agroforestry systems, (b) development of financial instruments adapted to agroecological transitions, (c) empirical validation of the model in different biogeographical contexts, (d) scalability analysis of community co-management platforms.

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Conflict of interest

Authors declare that they have no conflicts of interest.

Authors' contribution

All the authors reviewed the writing of the manuscript and approve the version finally submitted.



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