Research Article

Stakeholder linkage in conservation strategies: a qualitative tool for improving the management of a biosphere reserve in the Yucatan Peninsula, Mexico

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Abstract

Management strategies for biosphere reserves need to be locally linked, acknowledging the interests and expectations of local stakeholders, as their participation is crucial for effective resource conservation, particularly in the case of subsistence resource management. In this paper we present a novel qualitative analysis tool, called a linkage matrix, for evaluating the social linkage of biosphere reserve management instruments. As a case study we considered wildlife use for subsistence purposes in the context of Los Petenes Biosphere Reserve (LPBR), located in the northwest of the Yucatan Peninsula, Mexico. Based on official and ethnographic data on traditional wildlife use in two Maya communities neighboring the reserve, we documented its Management Program's degree of social linkage, and identified actions to improve its implementation in the zone of influence of the protected area. Based on the linkage matrix, the reserve Management Program was found to be highly inclusive, taking into account 64% of the interests and expectations identified by local peasant-hunters regarding wildlife. Nevertheless, marked deficiencies were identified in the implementation of the reserve's management instrument, which limited the effectiveness of the protected area for conservation. The linkage matrix enabled the identification of possible lines of action for improving both the specific content of the Management Program and its implementation regarding wildlife use. Based on a) the results of the linkage matrix in LPBR, b) the objectives of biosphere reserves aimed at conservation and development, and c) the requirement for biosphere reserves to implement an official management instrument, we highlight the scope of applicability and the contribution of our analysis tool, which offers a means for approaching the social linkage of biosphere reserves not only in Mesoamerica but around the world.

Key words: Protected areas, wildlife management, qualitative analysis tool, Campeche, Mexico.

Resumen

En reservas de la biosfera, la vinculación de actores locales en las estrategias de manejo y conservación de recursos naturales es fundamental para la implementación efectiva de las mismas, especialmente en contextos de manejo de recursos naturales de subsistencia. En este estudio, presentamos una herramienta novedosa de análisis cualitativo, denominada matriz de vinculación, para evaluar la vinculación social del instrumento de manejo de reservas de la biósfera. Como un estudio de caso, consideramos el aprovechamiento de fauna silvestre con fines de subsistencia en el contexto de la Reserva de la Biósfera Los Petenes (RBLP), ubicada al noroeste de la Península de Yucatán, México. A partir de información oficial de manejo e información etnográfica sobre el uso tradicional de fauna silvestre en dos comunidades mayas aledañas a la RBLP, documentamos el grado de vinculación social de su Programa de Manejo, identificando acciones para mejorar su implementación en la región. Mediante la aplicación de la matriz de vinculación encontramos que el Programa de Manejo de la RBLP es altamente incluyente, al considerar el 64 % de los intereses y expectativas locales sobre la fauna silvestre. Sin embargo, se identificaron marcadas deficiencias en la implementación del instrumento en la reserva, limitando la efectividad de manejo en el área protegida y su zona de influencia. La matriz de vinculación permitió identificar posibles lineamientos de acción para

mejorar los contenidos del programa de manejo y su implementación en relación al uso de fauna silvestre. Basados en a) los resultados de la matriz de vinculación en la RBLP, b) el doble objetivo de conservación y desarrollo de las reservas de la biósfera, y c) el imperativo de las reservas de la biósfera de implementar su instrumento de manejo oficial, resaltamos el aporte de nuestra herramienta para abordar la vinculación social de reservas de la biósfera en Mesoamérica y el mundo.

Palabras clave: Áreas protegidas, manejo de vida silvestre, herramienta de análisis cualitativo, Campeche, México.

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Introduction

In protected areas, the participation of local stakeholders is crucial for the effective conservation of natural resources [1-5]. Currently research emphasizes that the adequate involvement of local actors in the design and implementation of management strategies: 1) promotes trust and learning in the inter actors in the long-term [6]; 2) restores the traditional rights of local stakeholders over the management of natural resources, promoting quality, legitimacy and durability in decision-making [3]; and 3) favors the integration of local and scientific knowledge resulting in a better understanding of the complex dynamics of natural processes [3], all of which lead to improved conservation results.

Unlike other protected areas, and given their dual purpose of conservation and socioeconomic development [7], biosphere reserves in Mexico consider the use of natural resources by the local population in accordance with the zoning of the reserve (*e.g.,* core zone and zone of influence), as established in their management programs. Nevertheless, inadequate regulation of natural resources that does not take into account local usage realities may lead to negative impacts, not only on biodiversity (*e.g.,* use of at-risk species), but also on rural populations (*e.g.,* affecting subsistence practices) that depend on wildlife species for survival [8-12]. As such, management strategies need to be "locally linked", acknowledging the interests and expectations of local stakeholders, particularly in the case of subsistence resource use [9, 13, 14].

In Neotropical environments, the rural population has historically used wildlife species for subsistence purposes [15-19]. It is estimated that wild animals constitute 30-50% of animal protein in the diet of rural populations, mainly in Central and South America [20, 21]. In rural zones of the Yucatan Peninsula, at least 15 wild vertebrate species continue to be used for subsistence purposes by part of the Maya population who still practice various forms of traditional hunting [16, 17, 22-24].

In the Yucatan Peninsula, Maya subsistence hunting has faced strong spatio-temporal restrictions with the establishment of biosphere reserves (*e.g.,* Los Petenes, Campeche; [25]), where the inadequate application of regulations on wildlife use is generating "conservation conflicts" (*sensu* Redpath *et al.* [10]). This could hinder the desired conservation of ecosystems and the promotion of social development in protected areas and their zones of influence [7, 26]. While each biosphere reserve must have an official management instrument (*i.e.,* management program) [27], the effectiveness of these programs in terms of conservation and their social linkage is generally unknown [9, 25, 28, 29, 30]. A lack of social linkage in management programs may be because they are generally developed by external agents with limited or no local stakeholder participation.

In this study, we present a novel qualitative analysis tool for evaluating the social linkage of a biosphere reserve management program. Recognizing the importance of Neotropical wildlife as a subsistence resource in contemporary Maya culture [17, 22, 31], we analyzed Maya subsistence hunting in the context of a biosphere reserve on the west coast of the Yucatan Peninsula. This case study inspired the linkage matrix, designed to act as a model for comparing official management actions in a reserve with the interests and expectations of local stakeholders in relation to one or several natural resources (*e.g.,* wildlife use for subsistence purposes). We emphasize that the adequate involvement of local stakeholders is essential in any effective management strategy [3, 5], increasing the potential for conservation and social development in biosphere reserves [26].
The linkage matrix, which evaluates the linkage of local stakeholders with natural resources management in a biosphere reserve management program, also has great potential for application in other priority areas for conservation in Mesoamerica, as well as in other biosphere reserves worldwide.

Methods

Area and study communities
Our case study is referred to Los Petenes Biosphere Reserve (LPBR, 20°31'- 19°49' N, 90°45'-90°20' W), located on the northwest coast of the Yucatan Peninsula. The climate in this region is warm and sub-humid, with a mean monthly temperature of 26°C and mean annual precipitation of 819 mm [32]. This precipitation is seasonal, with a dry season from December-May (mean monthly precipitation = 13.2 mm) and a rainy season from June-November (mean monthly precipitation = 149 mm) [33].

Los Petenes Biosphere Reserve is a federal protected area, that was established in 1999. It covers 282,857 ha (64% marine and 36% terrestrial) and has no human settlements within its borders [34]. The reserve includes an internationally renowned coastal wetland [35] where the vegetation is mainly composed of medium sub-deciduous forest, mangroves (*e.g., Conocarpus erectus*, *Rhizophora mangle*), secondary vegetation patches, xerophylic bush, natural grassland (*e.g., Typha dominguensis*, *Cladium jamaicense*) and agricultural fields [36].

Within the zone of influence of the reserve (which stretches some 1,125 km^2 along the terrestrial part to the west), there are 19 Maya communities that maintain a strong socioeconomic interaction with the protected area, practicing seasonal agriculture, subsistence hunting, apiculture, charcoal production, horticulture and coastal fishing [37]. Two of these Maya communities, El Remate and Los Petenes (references used by León and Montiel [22] and Méndez-Cabrera and Montiel [38]) have been studied by our research group, and local practices and perceptions of wildlife use have been extensively documented [*e.g.,* 9, 17, 22]. In both communities, it has been reported that peasant-hunters traditionally practice subsistence hunting in various forms (in group or *batida*, stalking, night-light hunting and opportunistic hunting), mainly aimed at obtaining white-tailed deer (*Odocoileus virginianus*), peccary (*Tajasu tajacu*), paca (*Agouti paca*) and ocellated turkey (*Agriocharis ocellata*). For a detailed sociodemographic description of these two communities and their local wildlife uses, see León [39] and Oliva *et al.* [9].

Ethnographic data and the official management of LPBR
The ethnographic data for this study came from previous work in Los Petenes and El Remate on local perceptions and expectations related to wildlife use [9]. These Maya communities comprise the two units of analysis for this case study. Semi-structured and in-depth interviews (both following the methodology proposed by Bryman [40]) were conducted with a total of 66 peasant-hunters identified by the local population in Los Petenes (62%) and El Remate (38%). Information was obtained on 1) the individual importance and community relevance of hunting; 2) individual expectations and collective regulations on hunting; and 3) customs and beliefs regarding hunting [9].

Based on the data gathered from the interviews and on participant observation (carried out by M. Oliva) undertaken in both communities, we identified the most representative and broadly socially recognized aspects expressed by local stakeholders regarding the resource of interest (*i.e.,* wildlife). These aspects comprised the local elements (LE) for this study (Appendix 1).

On the other hand, based on a detailed analysis covering the six themes (protection, management, restoration, knowledge, culture and administration) in the LPBR Management Program [37], we then identified 12 topics (Appendix 2) related to the regulation and use of the resource of interest (*i.e.,* wildlife), which enabled us to define 36 official management elements (OME). These elements comprised the official counterpart for the pairwise comparison of local elements by applying the linkage matrix described below.

The linkage matrix
In order to understand the linkage between the local elements (derived from the interests and expectations of local stakeholders) and the official management elements (derived from the LPBR Management Program) in relation to wildlife use in the reserve, we designed and implemented a linkage matrix. This novel qualitative analysis tool enabled us to integrate and compare the ethnographic data from our case study with official information contained in the Management Program.

The pairwise comparison (LE-OME) enabled us to clearly and adequately identify what the local stakeholders had expressed about the resource (in this case, wildlife) in the specific content of the reserve Management Program. These comparisons resulted in four possible categories for the way

in which the local elements were represented in the official management elements: 1) implemented explicit representation (IER), 2) non-implemented explicit representation (NIER), 3) ambiguous representation (AR) and 4) null representation (NR) (Appendix 3).

Data analysis
In order to analyze the content of the linkage matrix, we identified the correspondence (matching) or lack of correspondence (non matching) between compared pairs of elements (LE-OME), taking into account 1) the orientation, expectation and scope of what was stated by local stakeholders and the official Management Program; and 2) the observed aspects resulting from participant observation. Pairwise correspondence (between LE-OME) referred to an allusion or consideration, in the same regard, of an activity, practice or expectation in both local and official management elements. For example, an identified matching was that local expectations of carrying out alternative productive activities coincided with the premise established in the Management Program to promote such activities for the local population. Lack of correspondence resulted from discrepancies identified between each pair of elements. For example, we identified as a non matching the fact that peasant-hunters sell wild meat locally even though the Management Program states that this activity is prohibited.

In the linkage matrix, the representation of local elements in the Management Program was first defined based on the topic (Appendix 2). For example, in order to establish the relationship between a LE and the specific OME "closed seasons", the latter was considered to be part of the topic "provision of information". As such, it was the topic that guided the interpretation of the OME (stakeholders are not informed about closed seasons), and this interpretation differed if the OME corresponded to another topic, such as "sustainable management" (closed seasons are established as a sustainable management action) (Appendix 2). Subsequently, the OME defined the representational category (*i.e.,* implemented or non-implemented explicit, ambiguous, or null) for each comparison considered in the matrix.

Results
The linkage matrix showed that in the majority of cases (64%), the perceptions and expectations of peasant-hunters had at least one official management element that represented their local interests regarding wildlife use in the study communities. Of the 36 local elements evaluated in the linkage matrix, 58% had a non-implemented explicit representation, 25% an ambiguous representation, 11% a null representation, and just 6% an implemented explicit representation in the Management Program. The explicit representations (implemented and non-implemented) were found to be related to aiding local development, promoting productive alternatives, strengthening traditional productive activities, fostering local participation in wildlife management and promoting its sustainability.

On the other hand, the ambiguous representations mainly related to a lack of definition or clarity of key aspects (such as adaptive management or sustainability criteria) and requirements established in the Management Program, such as how to confirm the sustainability of subsistence hunting and the circumstances under which this activity is considered illegal. Null representation of local elements in the Management Program related to the official stance (with little basis) that subsistence hunting (and the local sale of wild meat) exerts strong pressure on wildlife in the region. Official management elements were identified that proposed a reduction in subsistence hunting or the prohibition of the local sale of wild meat. The null and ambiguous representations

(36% in total) in the linkage matrix referred to the topics of productive alternatives, local participation, hunting for self-consumption, conservation and the reduction of illegal activities.

Lines of action for managing wildlife

The linkage matrix enabled 10 lines of action to be identified for improving both the specific content of the Management Program and its implementation (Appendix 4). Regarding the official instrument contents, the following needs were identified: 1) to improve the definition of key concepts (such as subsistence, self-consumption, and adaptive management), 2) to include sustainability criteria that can be monitored by both local and external actors, and 3) to define the conditions under which subsistence hunting is considered an illegal activity.

An adequate implementation of the Management Program was found to require: 1) strengthening of communication and the provision of advice to local stakeholders by the reserve authorities, and 2) improvement of the regulation and handling of wildlife resources by means of greater involvement of local stakeholders.

Discussion

In our case study, the linkage matrix showed that the majority of local interests and expectations associated with traditional wildlife use were represented in the reserve Management Program. While the implementation of specific actions poses the greatest challenge for the management of wildlife in the region, the identification of lines of action via the linkage matrix constitutes significant progress towards defining priorities in this regard. As such, our tool allows the inextricable relationship between a biosphere reserve and its nearby local populations [12, 41, 42] to be tackled directly, promoting adequate identification and involvement of actors in regional conservation strategies [3, 5]. The linkage matrix is aimed at two specific target audiences: a) conservation workers interested in applying the tool, such as technical teams providing advice to decision makers (*e.g.,* biosphere reserve managers), government agency employees, independent consultants and non-governmental organizations (NGOs); and b) the academic community, as part of the academic debate on conservation, particularly regarding the involvement of local stakeholders in conservation strategies. It should be noted that the above mentioned conservation workers must be supported by specialists (*e.g.,* human ecologists) to collect the socio-ecological information related to local stakeholders' expectations and interests.

For the case study, the linkage matrix underscored the need to place greater emphasis on sociocultural variables, recognizing local elements that demonstrated the expectations of peasant-hunters regarding the use of a natural resource such as wildlife. The linkage matrix therefore provided a dual function in the evaluation of the Management Program. Firstly, in terms of its design and content, by considering explicit, null and ambiguous representations. The comparison between OMEs and LEs permitted the identification of specific content and operational aspects that were either consistent with the local context (*i.e.,* explicit representations) or were not consistent (*i.e.,* ambiguous and null representations). The case of null representations is of particular importance, as they identify conflicting issues derived from the Management Program. The second function of the matrix in evaluating the Management Program relates to its implementation, by considering whether the provisions of the Management Program are implemented (implemented explicit representation) or not (non-implemented explicit representation).

One of the main ambiguous aspects of the LPBR Management Program was the lack of clarity regarding the circumstances under which hunting for self-consumption is considered illegal, given that although it is permitted in the zone of influence of the reserve, the Inspection and Monitoring component of the Management Program considers it to be illegal. This represents one of the main obstacles to achieving the reserve's objectives of balancing the development of local populations and the conservation of natural resources [26], given that the Management Program's consideration of hunting to be illegal opposes the local practice of subsistence hunting. The requirement for the Management Program to confirm the sustainability of subsistence hunting also constitutes an ambiguous representation that hinders the implementation of the instrument. In order to implement sustainability, the objectives and strategies to be followed must be clearly stated with defined spatio-temporal scales [43], which is not the case in the LPBR Management Program.

In the Management Program, the *a priori* need to reduce the pressure on wildlife (from activities such as subsistence hunting) comprises one of the most significant null representations of the instrument with respect to local interests. This is due to the fact that there is no data on the state of the populations of the exploited species that permits the determination of a degree of excessive pressure on them. Application of the precautionary principle, as has occurred in this case, acquires greater complexity in social contexts where natural resources are used for subsistence purposes [9].

Based on the analysis of the results, the linkage matrix enables the identification of lines of action for improving the effectiveness of the reserve through highly contextualized recommendations for implementing its Management Program. This is of particular relevance given that the Management Program, which must be updated every five years (37), is currently undergoing its first update process. For more detailed results and discussion of the application of the linkage matrix in the case study, see Oliva [25].

The linkage matrix also has the potential to evaluate management programs in operation in other reserves, and improve their interaction with resident or neighboring human populations. Likewise, the matrix allows to capitalize available information (*e.g.,* ethnographic data) on socially relevant resources and to exploit it for the contextualization of management instruments (*e.g.,* management programs for protected areas, land-use planning, local and regional regulations on resource use). These must be socially linked, in order to promote their adequate implementation in the medium and long term.

It is important to note that the linkage matrix is viewed as a corrective tool applicable to previously designed management strategies with a view to improving their linkage with the corresponding application context (*i.e.,* local populations). In this regard, the matrix was not designed to replace community-based conservation initiatives. The tool is designed to deal with management and conservation strategies elaborated under a top-down approach whose linkage with local contexts must be evaluated because these have not necessarily been considered by external agents [44].

Implications for conservation

The social assessment of conservation strategies is a pressing issue within the global debate on conservation, which calls for them to be inclusive and to provide participatory dialog between actors and knowledge systems [41]. Biosphere reserves constitute the main conservation strategy that explicitly recognizes the inclusion of local populations as a key component for the effectiveness of the protected area [7, 26]. Considering this, and the fact that biosphere reserves must have an official management instrument [27] that incorporates these local perspectives, we stress the wide applicability of the linkage matrix to other reserves or priority areas for conservation within different sociocultural contexts. We highlight that the linkage matrix provides a means for integrating scientific knowledge about specific contexts (*e.g.,* local elements) into conservation policy and practice (*e.g.,* LPBR Management Program and its implementation), which has been recognized as a key component for biodiversity conservation [45].

In accordance with the criticism of current methodologies proposed for evaluating the effectiveness of management (see, for example, Enhancing our Heritage Toolkit [44]; RAPPAM [46]; METT [47]), our linkage matrix stresses the inclusion of local stakeholders and sociocultural assessments in natural resource use [42]. As was the case in the LPBR, the linkage matrix can act not only as an evaluation tool, but also as one to promote the effectiveness of management instruments and their implementation (by identifying lines of action for improving the management instrumentation of a reserve). This is extremely important, because the inclusion of local actors does not solely rest on their representation in a management instrument, but also on the effective implementation of that instrument. This effective implementation process is highly context-dependent and constitutes a major challenge in the creation and implementation of biosphere reserves. We highlight the importance of involving local stakeholders in management strategies in biosphere reserves, particularly in cases where the social use of natural resources still involves subsistence practices.

Acknowledgements

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Appendix 1. List of Local Elements (LE) derived from the interests and expectations of the local stakeholders regarding wildlife use and subsistence hunting in Los Petenes Biosphere Reserve, Mexico.

Local Element (LE)
Traditional subsistence hunting
Local sale of wild meat
Practice of hunting outside the core zone of the reserve
Peasants´ expectation to continue practicing subsistence hunting
Peasants´ expectation of the development of productive alternatives
Demand for productive alternatives
Willingness to participate in regulation
Local receptiveness of official information
Local receptiveness of official advice
The main species exploited are not classed as protected
Participation of local authorities on the Advisory Committee*

*The Advisory Committee is the "entity established by the General Act for Ecological Balance and the Protection of the Environment to ensure the participation of all social, academic, private and civilian actors and the different government entities in contributing to decision-making and their joint responsibility for conservation and management of the natural protected area" (CONANP, 2006).

Appendix 2. Topics and Official Management Elements (OME) related to wildlife use and subsistence hunting contained in the Management Program of Los Petenes Biosphere Reserve, Mexico.

Topics	Official Management Element (OME)
Local use of natural resources	Local development that balances sustainable resource use with meeting the needs of local populations. Hunting for self-consumption permitted under a scheme of sustainable use. Prohibition of the local sale of wild meat. Use of resources within the reserve, except in its core zone. Sustainable use of wildlife by means of adaptive management. Generation of alternatives for sustainable use.
Hunting for self-consumption	Control and monitoring of activities for hunting for self-consumption. Consideration of hunting for self-consumption as an illegal activity.
Conservation	Reduce pressure on the ecosystem and on critical resources (e.g. white-tailed deer) by promoting alternative productive activities. Strike agreements with local stakeholders to reduce threats to wildlife.
Local participation	Participatory monitoring activities by local committees. Sustainable wildlife management. Conservation of wildlife. Diversification, use and productive management of wildlife. Management of the reserve by means of the Advisory Committee.
Local development	Promotion of alternative productive activities. Strengthening and promoting traditional productive activities.
Sustainable management	Balancing conservation and subsistence activities. Incorporation of sustainable management into traditional productive activities. Reduce pressure on wildlife. Adaptive management of natural resources in the reserve.
Provision of information	General information on natural resource use. Guidance on obtaining hunting permits. Closed seasons. Guidance on making applications.
Productive alternatives	Generation of sustainable productive alternatives. Reduction of pressure on protected species. Evaluation of the feasibility of establishing farms of wildlife species of interest to the inhabitants. Establishment of a WCMU*.
Advice	Conservation of wildlife resources. Development of productive activities.
Inspection and	Reduction in the loss of wildlife by means of coordinated actions between

monitoring	local and external authorities for the control and monitoring of hunting activities for the purpose of self-consumption, local sale or sport.
Species management	Protection of species contemplated in NOM-059**. Propose recovery projects when species suffer problems or their populations are reduced. Joint management plans with the Advisory Committee.
Reduction of illegal activities	Hunting.

*WCMU: Wildlife Conservation Management Unit.

**NOM-059: Official Mexican Standard on protected native species of wild fauna and flora in Mexico.

Appendix 3. The linkage matrix

Comparative analysis tool that compares two aspects: 1) the local realities of natural resource use (*e.g.,* wildlife) that are recognized by stakeholders, and 2) the content shown in the official management instrument (*i.e.,* management program) for biosphere reserves (*i.e.,* Los Petenes, Campeche, Mexico). In the matrix, the comparisons are based on the ability to clearly identify the representation of what was expressed by stakeholders (conceived of as 'local elements' – LE) in the specific content of the management program (conceived of as 'official management elements' – OME) for a certain resource. These comparisons result in four possible degrees of representation with their respective relationship bases.

Components of the matrix:
Topic. Content of the official management instrument associated with a set of representative use and/or management characteristics of a natural resource (*e.g.*, wildlife). In the case of Los Petenes, 12 topics were identified: 1) Local use of natural resources, 2) Hunting for self-consumption, 3) Conservation, 4) Local participation, 5) Local development, 6) Sustainable management, 7) Provision of information, 8) Productive alternatives, 9) Advice, 10) Inspection and monitoring, 11) Species management and 12) Reduction of illegal activities. These topics group together the 36 official management elements presented in the global matrix.

Official management element (OME). Premise, expectation or official regulatory guideline for the management of natural resources (*e.g.,* wildlife), identified based on the specific content of the management program. In the matrix, the presentation of each OME seeks to reflect, as far as possible, the nature, scope and exact statements of the content of the official management instrument.

Local element (LE). Widely socially recognized attribute of natural resource use (*e.g.,* wildlife), identified and represented based on 1) the opinion, point of view and expectation of the stakeholder (e.g. peasant-hunter), and 2) observations and empirical approaches (*e.g.,* interaction with the local population, participation in hunting trips) resulting from participant observation in the community.

Topic and Official Management Element (OME)	Local Element (LE)	Representation of the LE in the OME				Bases of the relationship (OME-LE)
		IER	NIER	NR	AR	
1. Local use of natural resources 1.6. Generation of alternatives for sustainable use	Demand for productive alternatives		✓			The alternatives that attempts have been made to establish in the zone of influence of the reserve are not viewed as viable alternatives for the local population.

Section of the matrix that shows its components and the representation of the local reality of use of a natural resource in the official management instrument. For example, a topic is shown with one of its official management elements (OME) associated with a local element (LE) and the respective representation category. In the final column, the basis of the OME-LE relationship is explained for the non-implemented explicit representation category (✓) in this example. Note the direction of primary representation (indicated by the arrow) of the local element of natural resource use in the official management instrument of the reserve.

Representation categories and their bases:
Implemented explicit representation (IER). Precise mention of or direct reference to a local element in the management program. This representation was established based on the existence of relevant content between pairs of local and official management elements, the implementation of which was mentioned by local actors and was locally observed (by the researcher).

Non-implemented explicit representation (NIER). Precise mention of or direct reference to a local element in the management program. In contrast with an IER, the lack of implementation was mentioned by local actors and confirmed locally (by the researcher).

Null representation (NR). Official mention or reference in contrast with the local reality of use of a natural resource (*e.g.,* wildlife). This representation was established based on contradictions, gaps or omissions identified in relevant content between pairs of local and official management elements.

Ambiguous representation (AR). Lack of clarity in the definition of official management concepts, criteria or parameters (*i.e.,* OME) that prevent the reliable and direct assignment of the representation (explicit or null) between pairs of local and official management elements.

Bases of the relationship (OME-LE). Empirical information that supports the representational category established for each of the local and official management elements.

Appendix 4. Suggested lines of action based on the linkage matrix, divided into two groups: 1) *Communication and advice*, and 2) *Regulation and management of wildlife resources.* For each line of action, the corresponding description is provided.

Lines of action	Description
Communication and advice	
Advice and official consulting mechanisms	On sustainable management of wildlife, on generating and establishing productive alternatives, on conservation, on promoting compliance with the regulations of the Management Program.
Local consultation	To identify sustainable productive alternatives that meet the needs of the local population.
Promotion of local participation	Inclusion of local authorities on the reserve Advisory Committee, participation of the community in the design and implementation of management strategies.
Provision of forums for local expression	For example, community meetings, to promote local participation in management.
Strengthening of channels of communication	Between local and external actors, to favor local participation in management and promote transparency in management.
Informing local stakeholders	About the regulatory guidelines on wildlife use established in the Management Program.
Regulation and management of wildlife resources	
Population studies on the species of interest	To understand the state of these populations, and thereby establish sustainable use rates.
Local monitoring	Establish joint monitoring programs (*e.g.,* local stakeholders and reserve authorities) as a way of promoting local participation in management and obtaining basic data for the management of wildlife resources.
Temporary signage of reserve zoning	To emphasize the illegality of certain practices (*e.g.,* hunting) in accordance with the zoning of the reserve; to clearly demarcate the borders of the reserve.
Appropriate controls	To carry out controls in accordance with the zoning of the reserve and the activities permitted or prohibited in each zone (*e.g.,* restriction of activities in the core zone of the protected area).