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Review

A Social–Ecological Systems Framework as a Tool for Understanding the Effectiveness of Biosphere Reserve Management

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Abstract: Biosphere reserves aim to reconciliate social and economic development with biodiversity conservation through complex spatial and governance arrangements. However, there is a generalized lack of information about how biosphere reserves are being managed and governed, and at what point their goals are being achieved, which limits a better understanding of the factors influencing biosphere reserve management effectiveness. Building on a systematic review of existing empirical studies, we developed a framework that identifies the main features related to biosphere reserve management effectiveness. We identified four main categories—context, inputs, process and outcomes—and 53 sub-categories, which interact at different scales and shape biosphere reserve effectiveness. We found that the capacity of biosphere reserves to achieve their goals is not only related to the way they are managed/governed, or to the inputs invested, but to many social and ecological contextual factors. We also identified benefits and impacts that were associated to biosphere reserves around the world. Comparing to other social–ecological system frameworks, ours provides a more inclusive approach, since it integrates the findings of studies with different research perspectives, considers a plurality of values attributed to natural resources, and the social–ecological system's scales dynamics.

Keywords: biodiversity; biosphere reserve; conservation; framework; governance; management effectiveness; protected area; social–ecological system; sustainable development; systematic review

1. Introduction

1.1. Biosphere Reserves and Social–Ecological Systems Management and Governance

Biosphere reserves are unique places to understand how to sustainably manage and govern social–ecological systems, given their integrated approach to conserve biodiversity and promote sustainable development, and their global scope. Along the manuscript we use the term "management" to refer to procedures and activities that are pursued in order to achieve given goals [1], and "governance" to address how and who make the decisions [2]. The designation of biosphere reserves is the main instrument for the implementation of the United Nations Educational, Scientific and Cultural Organization Man and Biosphere Programme (UNESCO-MAB) [3], which to date contains 669 designated places, distributed over 120 countries [4]. The first biosphere reserves were designated in 1976 to conserve natural areas and their genetic material [5]; however, in 1996,

their goal and functions were altered in order to accommodate sustainable development along with biodiversity conservation goals [6]. Biosphere reserves are now "sites of excellence to explore and demonstrate conservation and sustainable development on a regional scale" [6]. Each biosphere reserve is expected to fulfill three functions: biodiversity conservation, sustainable development, and a logistic support function that is related to research, training and education [6]. In order to achieve these functions, biosphere reserves have to meet the designation criteria, which includes the implementation of a zoning scheme: a legally constituted core area of adequate size to meet the long-term conservation objectives, surrounded or contiguous to a buffer zone, where activities consistent with the conservation goals can be performed, and a transition zone, where sustainable resource management should take place [6]. Besides the zonation and dimension requirements, biosphere reserves have to be relevant for the conservation of biodiversity within its biogeographic region, and provide arrangements to promote the participation of a range of stakeholders in the governance of the biosphere reserve, inter alia, public authorities, local communities and private interests [6].

The UNESCO Man and Biosphere Programme integrates key concepts from the social–ecological systems management and governance literature [7–9]. The goals of biosphere reserves are not only related to the conservation of biological diversity, but also cultural diversity, ecosystem services, and sustainable development [3]. Their logistic function places emphasis on the importance of learning, a key property of adaptive management [10]. Governance of biosphere reserves requires the inclusion of a diversity of actors, a property of co-management and polycentric governance. They can provide the arena where a diversity of organizations and stakeholders, at different scales or within the same level, interact. The role of bridging organizations is particularly important in this regard; to foster collaboration, build trust and resolve conflicts between the different stakeholders [11].

A big gap between the biosphere reserves concept and practice has been reported [12,13]. According to a report of the International Co-ordinating Council of the MAB Programme [13], a big majority of the designated biosphere reserves were not fulfilling the designation criteria, and only six (out of a total of 621) were considered to fully meet the criteria. However, a comprehensive understanding of biosphere reserve management effectiveness, i.e., if biosphere reserves achieve the goals for which they were designated (as defined in protected areas' management effectiveness literature [14]), is not available; note we use the terms "biosphere reserves' management effectiveness" and "biosphere reserves' effectiveness" interchangeably along the manuscript. The mechanism that evaluates biosphere reserves—the periodic review process—is considered inadequate to monitor management effectiveness, because it mainly focuses on evaluating the compliance with the designation criteria, and not its management and governance performances [15]. Besides that, the information available is scarce, not only because most biosphere reserves have not established any reporting until very recently [13], but also because the periodic reviews are not accessible. Assessment of biosphere reserve effectiveness (and of protected areas in general) is also hampered by the general lack of available data for biodiversity and social monitoring [16]. This situation limits the understanding of which factors may be related to success or failure of biosphere reserves and also their contribution for a better understanding of pathways towards more sustainable social–ecological systems.

Some large-scale studies have evaluated biosphere reserve management effectiveness and the factors that can be associated with its success or failure. However, these studies are not comprehensive because they analyze specific management/governance practices (e.g., Schultz and her colleagues analyzed how stakeholder participation and adaptive co-management influence the goals of biosphere reserves [17]), or their evaluations were only based on the perceptions of managers and researchers [17–19]. There is, therefore, a need to integrate the available studies, in order to have a more holistic understanding of the factors that influence biosphere reserve management effectiveness.

1.2. Social–Ecological Systems Frameworks and Biodiversity Conservation

Calls for an increasing integration of social–ecological systems concepts in biodiversity conservation have occurred in recent years [8,9,20,21]. Social–ecological systems (SES) are complex systems, in which the interdependence and interactions between both social and ecological systems across scales and time are recognized [22,23]. The study of SES has relied on the development of frameworks, theories and models which help to make sense out of these complex systems [24]. A framework is the structure of a theory, in which concepts and their relationships are displayed in a logical way [25]. Using a diagnostic perspective, frameworks are useful to understand the source of the poor outcomes of social–ecological systems [26]. Because frameworks are not as general as theories, or as precise as models, they are adequate to address the panacea problem in policy design [26]. Social–ecological systems frameworks differ, e.g. in the weight given to the ecological and social system, and in the conceptualization of the relationships between both systems [27]. Despite a diversity of frameworks having been developed to better understand SES [27], there is not a single framework that can be considered fully comprehensive, and different frameworks highlight different components of the same problem [28].

Ostrom's social–ecological systems framework [29] is particularly relevant in the context of natural resource management and governance. The framework integrates the findings of a number of case studies around the world where communities self-organize to manage natural resources of which excludability is not possible, e.g., forests, fisheries and groundwater systems [29]. Ostrom's framework has, however, some limitations that make its adaptation to conservation policies limited [9]. The main focus of Ostrom's framework in common-pool resources has raised questions about at what point the framework can also be used with public goods and services, such as many ecosystem services [30]. Besides that, biodiversity conservation frequently imposes restrictions on natural resource use, and therefore, there is no process of extraction, which is a cornerstone in Ostrom's framework [30]. Its emphasis on single focal situations, that develop mainly at one scale, fails to account for the linkages and dynamics of SES across scales [9]. Although some of Ostrom's rules may be useful at larger scales [31,32], its application faces many challenges [32] due to the increased level of complexity associated with such large-scale systems [33]. Ostrom's framework has also been criticized for its focus on institutional theory, failing to account for other perspectives on SES [9].

In order to overcome the limitations regarding biodiversity conservation issues, Ostrom's framework has been combined with other frameworks, such as resilience theory and systematic conservation planning [9,21]. These frameworks are, however, not fully comprehensive, and build mainly on conceptual instead of empirical analysis. Therefore, a social–ecological systems framework that considers the existing empirical knowledge about integrated strategies for biodiversity conservation and sustainable development remains to be developed. We argue that biosphere reserves represent unique opportunities to develop such a framework.

1.3. Study Goals

In this study, we reviewed existing empirical literature about management and governance of biosphere reserves in order to develop a holistic framework which represents its main features. By doing this, we aim to:

(i) Provide a more comprehensive understanding of factors related to biosphere reserve management effectiveness and;
(ii) Contribute to a better understanding of factors, which are important for the integrated management of social–ecological systems and the conservation of biodiversity.

2. Materials and Methods

The literature used to identify the main factors associated with biosphere reserve management effectiveness was selected using existing approaches for systematic reviews [34,35]. The review

process followed other systematic literature reviews [34,36,37], and included a systematic procedure for paper selection (steps 1 to 5), and the development of a category scheme (step 6) through a stepwise deductive–inductive coding procedure (Table 1). A schematic representation of the methods is also given in Appendix A.

Table 1. Review procedure adapted from other systematic literature reviews [34–36].

Review Step	Procedure	Results
1. Data gathering	Database search on Scopus using the defined search string.	Bibliographical information of 2499 potentially relevant papers
2. Data screening	Screening of the data to define the inclusion criteria. Papers published before 1996 were excluded.	Data set reduced to 2286 potentially relevant papers
3. Data cleaning	Screening the title, abstracts and keywords guided by the questions: (i) Is the study engaged with the biosphere reserve concept? (ii) Is the study about management or governance of biosphere reserves? Is the study useful to understand the factors influencing management and governance of biosphere reserves? (iii) Is it an empirical study? 10% of the papers were evaluated by two reviewers and the different decisions discussed.	Data set reduced to 186 potentially relevant papers
4. Data scoping	Download of the potentially relevant papers.	Download of 177 papers (9 papers with no full-text access)
5. Paper classification	Definition of the scale of analysis resulted in the exclusion of those studies with more than one case study. Further papers were excluded because they were not developed in UNESCO biosphere reserves or they didn't comply with the criteria defined in step 3.	66 case studies
6. Categorization	"Thought units" were selected as the units of coding. The category scheme was developed through a backward and forward inductive–deductive approach, based on preliminary and recursive coding.	Category scheme with 4 categories and 53 sub-categories

2.1. Paper Selection

Existing literature was screened in the Scopus database on 10 March 2017. Different combinations of key-words along with "biosphere reserve", such as "management" or "governance", were initially used. However, the inclusion of these terms in the research string was excluding potentially relevant papers, and therefore, only "biosphere reserve" was used. We also limited the search to peer-reviewed papers published in English (research string in the Appendix B). We further excluded the papers published before 1996 because their empirical work was developed before the Seville strategy [6], when the goals of biosphere reserves were mostly focused on the conservation of biodiversity than on a more integrated social–ecological approach. The resulting subset of papers (n = 2286) was screened for the definition of the inclusion criteria (Table 2).

Table 2. Description of the criteria used to decide the inclusion/exclusion of a paper.

Criteria	Description
Engagement of the study with the biosphere reserve concept	Studies performed in biosphere reserves, or that engage with them in some way, e.g., studies realized in adjacent areas, but which report implications for the biosphere reserve.

Table 2. *Cont.*

Criteria	Description
Link with management or governance of biosphere reserves	A paper was considered to be about management or governance of biosphere reserves if it reported on specific actions that were associated with the biosphere reserve's decision-making body. Defining effectiveness against some pre-determined goals was not possible because the goals of the program are very broad (e.g., sustainable development) and different biosphere reserves have different, more tangible goals. Papers about why management or governance is performed in a specific way were also included. Besides that, we only selected papers about biosphere reserve management or governance, and not its designation, in order to exclude "paper biosphere reserves", i.e., those where active management is not in place.
Empirical study	An empirical study includes primary or secondary data but not "analysis of analysis", i.e., reviews or research synthesis [37]. A critical appraisal of the methods and results of the papers resulted in the elimination of those that do not present enough information for meaningful interpretation [38] and opinion papers. Studies using very different strategies (e.g., experiments, surveys, ethnographies) were included, in order to cover a diversity of inquiry belief systems or worldviews [39]. We acknowledge, however, our limitations in doing so, since reviewers bring with them their own research philosophies, which will influence not only their strategies and methods, but their perceptions on what is important or useful to consider [39].

The conformity of the papers with the inclusion criteria was made by screening the title, abstract and keywords of each paper. The full-texts were screened by the first author, and a precautionary approach was taken—if a paper was perceived to potentially present relevant information, it was included. A portion (10%) of the papers were randomly selected to be evaluated by a second reviewer (the second author), and disagreements were discussed and resolved. This helped with building a common understanding and minimizing bias during the process of paper selection [34]. The application of this criteria resulted in the selection of 186 potentially relevant papers. This subset was downloaded, and when the full-text was not available, emails were sent to the authors. The analysis of the 177 available full-texts resulted in the further exclusion of those papers that: (i) were developed in biosphere reserves that are not included in UNESCO available databases [4,40]; or (ii) included more than one biosphere reserve, or biosphere reserves and other instruments, in multiple case-studies. We acknowledge that by including papers that developed studies in only one biosphere reserve, potentially relevant literature of the field may be excluded from our analysis (e.g., [15,17,19,41]). Many of these papers were, however, included in the discussion of the framework that resulted from our analysis in Section 4.1. Further papers were iteratively eliminated because they did not comply with the inclusion criteria previously defined. The final number of papers which were used in the next step of the review was 66.

2.2. Development of the Categories

The categorization procedure followed the one proposed by Srnka and Koeszegi [36], which is broadly represented in Appendix A. Only the results section of each paper was coded, using NVivo (QSR International, Doncaster, Australia; version 11.4.1.1064). In order to identify general themes, we analyzed the results sections of the papers, looking for repetitions, similarities and differences, and causal relations in the text [42]. Three main subjects emerged: factors influencing management/governance, management/governance processes, and outcomes. The coding started with an inductive analysis, where codes were assigned to thought units, i.e., text chunks without a pre-defined length but in which a main idea is expressed [36]. The codes were organized in the general topics previously identified; however, along the coding procedure, the main categories changed to

reflect the topics that were emerging from the data. The codes were developed in hierarchies in order to obtain a detailed and precise category scheme [36]. The coding was performed in a stepwise procedure, in which the data of an increasing number of random papers was assigned to codes. At each step, the coding scheme was reviewed in order to incorporate the new data from the group of papers just coded, but at the same time keeping it at a manageable size. In parallel, existing literature was used to help make sense of the data (deductive approach). When about half of the papers were coded, the scheme had four categories and 113 sub-categories. The scheme continued to be interactively changed and simplified, a process that was supported by the discussion of the coding process between the authors of this paper, including comparing different coding solutions, and by checking with existing literature. A second round of coding was performed in which the first papers coded were coded again. The coding scheme continued to be interactively changed in a similar way as in the previous steps, until it was perceived to capture most of the information in the papers. About 20% of the papers were coded a second time (recursive step). The final scheme, with four categories and 53 sub-categories, was found to be the most relevant and plausible solution; however, other criteria could have been conceptualized out of the available data. Clear definitions were provided to categories and sub-categories.

3. Results

The systematic selection of the papers resulted in the inclusion of 66 case-studies for further analysis, i.e., less than 3% of the peer-reviewed English literature with the term "biosphere reserve" present in the title, abstract or keywords. Reviewed papers are listed in Appendix C. As a result of the categorization procedure, four categories and 53 sub-categories, which represent factors related to biosphere reserve management effectiveness, were defined. The interactions between these factors across scales result in a dynamic system, which is generally depicted in Figure 1.

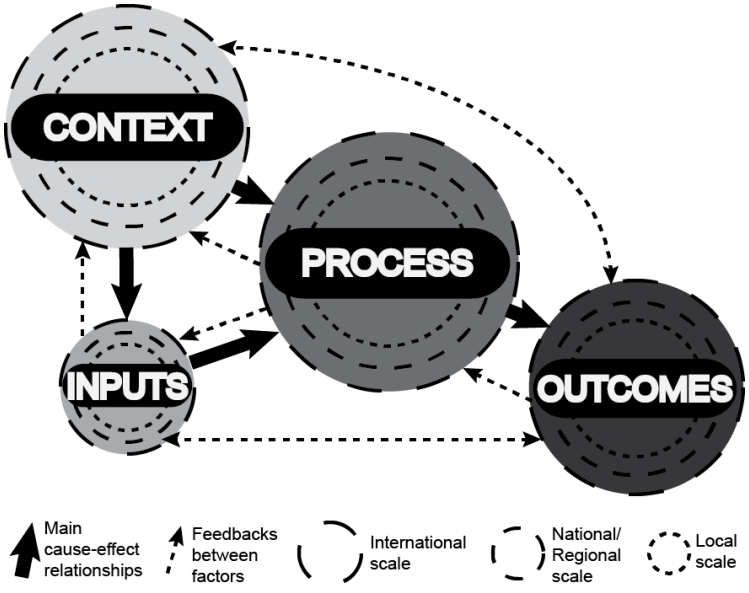

Figure 1. A framework to understand biosphere reserve management effectiveness. The figure represents the four core categories that emerged from the empirical literature about the management and governance of biosphere reserves, and highlights the interactive nature of factors influencing management effectiveness across different scales. Core category size is representative of the number of sub-categories included: 18 in the process, 17 in the context, 13 in the outcomes and five in the inputs. Different factors are represented by the different intensity of color of each category and distributed across different scales. The lack of clear boundaries between factors in different categories and scales is represented by the dashed circles. The area of the circles is only illustrative, since information about the number of factors that are important at each scale have not been systematically accessed.

Four core categories were developed: context, inputs, process and outcomes. In the context category, we include place-based and multiscale features, which their presence or absence shape the settings where biosphere reserves are implemented. The inputs category embraces material and immaterial investments in the process. The process category includes factors related to management and governance per se, i.e., those actions and mechanisms which are associated with biosphere reserve decision-making. Finally, in the outcomes category, we included the impacts and benefits in social and ecological systems that followed the implementation of the process. These factors were associated with sub-categories, as depicted in Table 3 and defined in Appendix D.

Table 3. Categories (context (C), process (P), inputs (I), outcomes (O)) and sub-categories (C1, C2, etc.) that emerged from the literature about the management and governance of biosphere reserves. Sub-categories are organized in thematic groups (in quotation marks) for better understanding.

Context (C)	**Process (P)**
"Institutions and organizations"	"Project and spatial dimension"
C1 Regulations—formal rules	P1 Process scale
C2 Informal institutions and culture	P2 Spatial design
C3 Power issues	"Decision making"
C4 Organizations	P3 Process initiation
"Time related"	P4 Public participation
C5 Historical factors	P5 Participatory processes
C6 Time	P6 Management body
"Socio-economic attributes"	P7 Coordination and leadership
C7 Economy and politics	P8 Institutions for management
C8 Socio-economic attributes	"Instruments"
C9 Information related	P9 Material investments and infrastructure
"Purpose of natural resources use"	P10 Human resources related
C10 Use of natural resources for livelihoods	P11 Conservation and habitat management
C11 Use of natural resources for cultural purposes	P12 Restrictions
"Human-nature relationship"	P13 Enforcement and control
C12 Impacts on natural resources	P14 Incentives
C13 Human–wildlife conflicts	P15 Economic development
C14 Cultural landscape	P16 Research and monitoring
C15 Conservationist value	P17 Information and capacity building
"Ecological context"	P18 Planning
C16 Bio-physical attributes	
C17 Resource mobility	

Inputs (I)	**Outcomes (O)**	
"Attitudes and beliefs"	"Benefits"	"Impacts"
I1 Attitudes	O1 Economic	O8 Economic
I2 Beliefs	O2 Social	O9 Social
"Investments"	O3 Empowerment	O10 Inequality
I3 Funding and material support/opposition	O4 Health	O11 Health
I4 Non-material support/opposition	O5 Learning	O12 Cultural
I5 Type of knowledge	O6 Cultural	O13 Environmental
	O7 Environmental	

A total of 53 sub-categories were identified: 17 in the context category, 5 in the inputs category, 18 in the process category and 13 in the outcomes category. "Context" includes features related with social systems, such as the organizations and institutions in place; human–nature interactions, such as human–wildlife conflicts; and ecological features, such as the presence of species with high mobility (e.g., migratory species). "Inputs" includes the attitudes and beliefs actors express in relation to the process; material and immaterial support/opposition; and the type of knowledge (scientific and/or experiential knowledge) that was used as an input for the management/governance. "Process" relates mainly with decision making procedures and the instruments used for management, but also with its scale (project vs biosphere reserve management/governance), and process spatial design (features related with, for example, spatial zoning, area and location). "Outcomes" reports economic benefits and impacts, such as the increase/decrease of jobs; positive or negative changes linked with social and

cultural features, such as empowerment and creation/deepening of inequalities; and environmental benefits and impacts, such as the increase/decrease of endangered species populations.

The factors that influence biosphere reserve management effectiveness occur at different scales. At an international scale, a financial crisis, included in the sub-category economy and politics (C7), was reported in the study of Trillo-Santamaría and Paül [43]. National government material and non-material support (included in the sub-categories I3 and I4) was important in the study of Devine [44]. The same study reported on the local degradation of natural assets inside the reserve (sub-category C12—impacts on natural resources). Factors also occur at different time scales—impacts of colonialism (sub-category historical factors; C5) were identified to still be important today in the study of Lyon and his colleagues [45]. A diversity of actors was also covered, of which relevance varies between different factors. Examples of relevant actors in different sub-categories include: beliefs of managers of biosphere reserves (sub-category I2, [46]); material support of the national government (sub-category I3, [43]); and economic impacts in local communities (sub-category O8, [47]). In Appendix E, a scheme demonstrating how the different components of the framework can interact is given.

4. Discussion

4.1. Factors Influencing Biosphere Reserve Management Effectiveness

In the proposed framework, we identified 53 sub-categories which represent different factors that influenced biosphere reserve management effectiveness around the world. We included outcomes as influencing factors, because of the feedback between them and the other sub-categories. The high number of factors in the proposed framework combines aspects of different global and regional studies, which highlight the importance of factors related to the management/governance process [18,19], the inputs, and the socio-economic and institutional context [48,49]. In addition, our framework considers the importance of contextual variables related to the existing ecological characteristics, and to the interaction and interdependence between the ecological and social systems. The reviewed literature report conflicts that emerged because of restrictions to natural resource use were applied in contexts where communities are highly dependent on them for their livelihoods (e.g., [50]). In other studies analyzed, existing conflicts between humans and wildlife (for instance, the depredation of livestock by predators [47]) required some interference by managers, such as compensation for the economic losses. In both situations, managers face challenges that may not exist in other biosphere reserves and therefore have to correspondingly adapt the management/governance process.

Many factors related to the way that biosphere reserves are managed and governed were identified in the reviewed literature. The implementation of biosphere reserves is taking place by using a variety of instruments related to the MAB programme goals [3,6]. Biodiversity conservation and the sustainable use of natural resources is promoted through conservation and habitat management initiatives (P11), restrictions (P12), enforcement and control (P13) and incentives (P14). Incentives (P14) and economic development (P15) are related to the biosphere reserve's sustainable development goals. The logistic function of biosphere reserves is being implemented through research and monitoring (P16) and information and capacity building (P17). Although we have not accessed if all biosphere reserves are working towards the three goals, the identification of factors related to instruments to achieve the sustainable development and logistic support goals is indicative that there are already biosphere reserves moving from their previous conservation focus [9].

According to the MAB programme [3], community participation should take place at many stages of biosphere reserve implementation. Many studies have highlighted the importance of public participation for the success of biosphere reserves [17–19], and ours is no exception (sub-category P4). However, the way participatory processes are developed (P5), including who participates, in which moments and the available information, was also found to be important (e.g., [51]). Other relevant factors related to the decision making include the way the process was initiated (top-down,

bottom-up or mixed; P3), the degree of centralization of the management body (P6), coordination and leadership (P7), and which institutions (P8)—formal or informal—are mainly used for management.

In the Section 1.1, we discussed how the assessment of biosphere reserve management effectiveness is hampered by the lack of an adequate evaluation mechanism and indicators. We overcame this by inductively identifying the changes resulting from the implementation of the process instead of evaluating effectiveness against some predetermined goals. We identified remarkable achievements following biosphere reserve implementation, such as empowerment (O3) and learning (O5). We followed existing definitions of empowerment [52] to include in this sub-category those situations in which local communities are given the responsibility and decision making of managing their own resources. This was reported in the Sian Ka'an Biosphere Reserve in Mexico, where fishermen participated in the definition of new no-take marine zones [53]. Evidence of social and transformative learning (as defined by Armitage and his colleagues [54]) were reported in the Kristianstads Vattenrike Biosphere Reserve in Sweden. In this biosphere reserve, politicians have changed their perceptions about the importance of informal gatherings, and developed new processes accordingly, such as the "environmental breakfasts", to discuss the environment with farmers [55].

The implementation of biosphere reserves is also associated with negative social and environmental changes. In the Waterberg Biosphere Reserve (South Africa), up-scale tourism, based on the creation of luxury spaces where "ordinary man" can't afford to visit, is being developed [45]. We included this unequal access to the cultural benefits arising from ecotourism development in the inequality subcategory (O10). The same study reports environmental impacts (O13) deriving from the development of this kind of tourism; in particular, the unsustainable use of water. We believe this example is demonstrative of the need for more clear guidelines regarding what "sustainable development" means in a biosphere reserve: at what environmental expense can development take place? Is equality a less important goal than providing environmental and economic benefits?

During the framework development, the importance of three main scales emerged: local, regional–national and international. We identified factors related to natural and social processes which are relevant at regional or global scales, e.g., migratory species life cycles and aspects related to globalization. The importance of scale and cross-scale dynamics are increasingly recognized in environmental management, in particular the mismatch between biophysical systems and their management and governance structures [56,57]. Biosphere reserves are in a privileged position to address scale mismatches, given their global network and their role as arenas where a diversity of stakeholders at different scales interact. Studies on collaboration networks may provide useful insights in this regard by analyzing cooperation and communication strategies between the different actors [58,59].

A social–ecological system understanding of biosphere reserve management effectiveness, as displayed in our framework, revealed many factors that were overlooked in previous studies. We acknowledge that our framework is not fully comprehensive, and that different criteria could have been conceptualized out of the available data. The integration of more studies, including from grey literature or potentially sub-represented regions, would be important. A better conceptualization of some sub-categories e.g., attitudes (I1) and beliefs (I2), is also needed to avoid confusion between them. Despite that, we consider that the framework brought a higher tangibility to some factors, in particular those related to how biosphere reserves are being managed and governed, and which contextual factors could be important, which are frequently referred to at a high abstract level (e.g., [48]). Furthermore, this framework shows that social and ecological benefits and impacts have been associated with the management and governance of biosphere reserves, which, to our knowledge, has never been systematized. We acknowledge that a better understanding of the factors that consistently led to benefits or impacts of biosphere reserve management and governance is necessary; however, at this point, these cause–effect relationships were not possible to systematize. Future work is needed in order to better understand the system dynamics. Also, the spatial distribution of the sub-categories identified would lead to a better understanding of the main patterns related

to the context, inputs, process and outcomes of biosphere reserve management and governance. The framework is, therefore, a first step towards a more holistic systems analysis of biosphere reserve management effectiveness. It can further inspire management and governance of biosphere reserves at different scales, e.g., through the definition of specific third-level variables, the framework may provide a structure for the development of criteria for the establishment and evaluation of biosphere reserves, as Pool-Stanvliet and her colleagues [60] have developed for biosphere reserves in South Africa. It may also be useful to systematically report experiences with management and governance, as Plummer and his colleagues [61] have proposed in relation to adaptive co-management processes. Such systematization can provide a better understanding of factors associated with positive and less positive outcomes and, eventually, the identification of the factors in the system that may leverage biosphere reserves success. The framework also provides a structure to comprehensively analyze literature about management and governance of biosphere reserves, and identify major trends and research gaps. Considering its operationalization, the framework should be regarded as a flexible tool in which sub-categories may be added or eliminated, or some may even change between the four main categories, in order to better address the challenge at hand.

4.2. Biosphere Reserve Framework and Social–Ecological System Frameworks

Our framework connects different fields of knowledge and provides a comprehensive understanding of the factors related to sustainable management and governance of social–ecological systems. It is a social–ecological framework in which dynamics of social, ecological or social–ecological aspects are linked across different scales and time. It has empirical support since our categories emerged from the results section of previously selected peer-reviewed empirical papers. The mixed inductive–deductive coding process allowed the incorporation of previously developed ideas from social–ecological systems literature (the Ostrom social–ecological systems framework [29]), social–ecological systems and protected areas [9,20], biosphere reserve effectiveness [48], and environmental management [62]. Other references used are identified in the sub-categories description (Appendix D). Because our framework included studies from a diversity of researchers, it embraces their different world views, research strategies and methods, making it more comprehensive than a single-study analysis. This diversity is required in the study of complex systems because it allows the incorporation of different perspectives in the management and governance of systems that are highly uncertain and poorly understood [10]. We do not claim, however, that our framework is value-free, and this is particularly relevant considering that the categorization process was primarily developed in an inductive way. In order to increase the reliability of the review procedure without compromising its validity, we included multiple reviewers in both the selection of the papers and categorization process and we carefully disclosed the coding procedure, as recommended by Srnka and Koeszegi [36]. Our framework follows, therefore, the major criteria Cumming [63] has proposed for the development of theory-driven social–ecological system frameworks. Despite being accomplished through the analysis of biosphere reserve management and governance, the proposed framework may also contribute to the advancement of theory in social–ecological systems.

Compared to other SES frameworks, we identified the same number of sub-categories as Ostrom's second-level variables [29]. We found many variables in common with Ostrom, e.g., the mobility of resources, monitoring and sanctioning processes, socio-economic attributes of users, norms/social capital and the importance of the resource. Ostrom's framework places more emphasis on the ecological variables and variables related to the process of extraction (e.g., harvesting levels and the number of users). We found that existing conservationist values are also important because it triggers the interest and actions of actors at different scales, which will change the local social settings. We also identify many variables related to existing power relations, which are absent in Ostrom's framework (e.g., historical factors, power issues and inequality). These differences can be related to the broader scientific perspectives we have embraced in the literature included, comparing to Ostrom's roots in an

institutional analysis. In Table 4, we provide a comparison between some aspects that may explain the differences between both frameworks.

Table 4. Aspects of the Ostrom's [29,64] and biosphere reserve frameworks which may explain the differences between them. The comparation is performed with Ostrom's initial work and excludes more recent updates to the framework, e.g., [30].

Aspect/Framework	Ostrom	Biosphere Reserves
Goal	Understand factors that affect the likelihood of self-organization for natural resource management	Understand factors that affect biosphere reserve management effectiveness
Scale	Small-scale, usually a common-pool resource (e.g., forest, fisheries, groundwater)	Local to international scales—some case studies focused on the management of a specific task, while others focused on the management of a transboundary biosphere reserve
Public/private nature of the resources	Mainly common-pool resources; public goods and socio-technical systems to a smaller extent	Diverse: private, common or public goods and services
Biodiversity values included	Economic values	Economic and non-economic values (e.g., fundamental and eudemonistic values [65], associated with the core and buffer zones)
Governance actors	Local communities	Diverse: governments, communities, non-governmental organizations, and/or multiple ways of collaboration between them
Roots	Institutional theory, collective action theory, rational choice theory and institutional change	The framework was developed to reflect the theoretical perspectives of the authors of the included studies (e.g., political ecology). The influence of the reviewer's disciplinary background (ecology) cannot, of course, be discarded
Based in blueprint solutions?	No	Yes, to some extent (e.g., strict protected core area)

Our framework is also consistent with other social–ecological frameworks. We agree with Cumming and his colleagues [24], who emphasize the relevance of scales for the effectiveness of conservation strategies. It is also consistent with the framework developed by Plummer and his colleagues [61], concerning adaptive co-management initiatives. Using a similar structure, based in settings, antecedents, process and outcomes, the authors developed a set of sub-categories, which are particular important regarding the processes of learning and collaboration. Both frameworks differ in respect to many of the sub-categories identified and how are they arranged in the four main categories. We also provided a more exhaustive identification of most of the sub-categories, and a clear recognition of the importance of the context, feedback and scales across all categories. Therefore, besides being consistent with the frameworks discussed [9,29,61], our framework adds new information, and provides a more holistic perspective on social–ecological systems management and governance.

5. Conclusions

Current and predicted high rates of biodiversity loss [66,67], along with high variability, uncertainties and ignorance about the ecological systems [68] constitute a large challenge for the sustainable management and governance of social–ecological systems. Biodiversity conservation strategies are required because of the role biodiversity plays in the provision of ecosystem functions and structure, from which human well-being ultimately depends [68], but also because of the value that biotic resources have on their own. Our framework reveals that the cross-scale interlinkages

between those social and ecological systems where conservation strategies are implemented cannot be overlooked, contributing a better understanding of management and governance of social–ecological systems along with the conservation of biodiversity. Through the integration of a diversity of empirical studies about biosphere reserve management and governance, we were able to develop a framework which integrates multiple world views, research strategies and methods, providing a more holistic perspective of social–ecological systems. Our framework reveals that a big diversity of factors potentially influence the capacity of biosphere reserves to achieve their goals. Biosphere reserves are not islands—they are influenced by the interlinkages of social and ecological contextual factors at different spatial and temporal scales. They are dependent on a set of inputs to be managed and governed, which are also associated with a diversity of scales and actors. The varied strategies used to manage and govern social–ecological systems in biosphere reserves are also important, because they trigger social and ecological changes, and not only in a positive way. The framework we propose may provide a structure to further analyze such complex system dynamics, and potentially reveal the sources of poor and successful outcomes in biosphere reserves and social–ecological system management and governance.

Biosphere reserves may offer a unique opportunity to understand pathways for more sustainable social–ecological systems. Their ambitious goals match the huge challenges we currently face, including halting biodiversity loss and ending poverty. We hope the proposed framework contributes a more holistic, systems understanding of biosphere reserve management and governance, and to its effectiveness, i.e., "a world where people are conscious of their common future and interaction with our planet, and act collectively and responsibly to build thriving societies in harmony within the biosphere" [3].

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Appendix A

Depiction of the major steps of the two stages of data analysis: the selection of the papers and the categorization process (adapted from the study of Srnka and Koeszegi [36]).

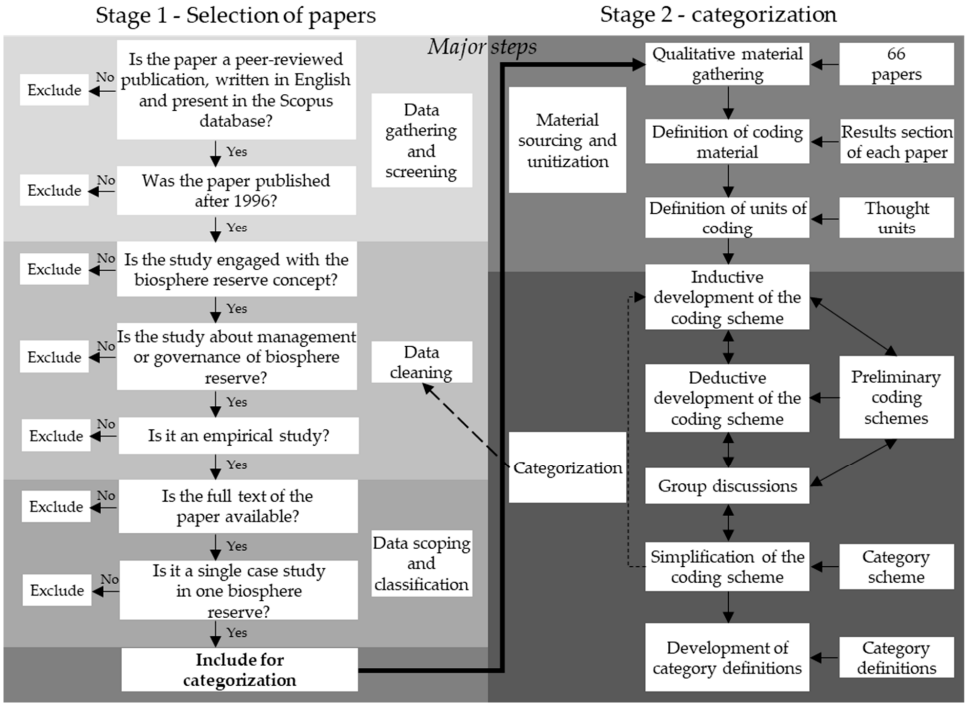

Figure A1. Main steps of data analysis.

Appendix B

Research string used to identify studies for review in Scopus database

TITLE-ABS-KEY ("biosphere reserve") AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "ip")) AND (LIMIT-TO (LANGUAGE, "English"))

Appendix C

Table A1. Reviewed articles. NA—digital object identifier (DOI) not available.

Author(s)	Title	Journal, Number (Issue), Pages	Year	DOI
Alonso-Yañez, G. and Davidsen, C.	Conservation science policies versus scientific practice: evidence from a Mexican biosphere reserve	Human Ecology Review, 20(2), 3–30	2014	http://doi.org/http://www.jstor.org/stable/24707624
Alonso-Yanez, G., Thumlert, K., and de Castell, S.	Re-mapping integrative conservation: (Dis) coordinate participation in a biosphere reserve in Mexico	Conservation and Society, 14(2), 134–145.	2016	http://doi.org/10.4103/0972-4923.186335
Azcárate, M. C.	Contentious hotspots: ecotourism and the restructuring of place at the Biosphere Reserve Ria Celestun (Yucatan, Mexico)	Tourist Studies, 10(2), 99–116	2010	http://doi.org/10.1177/1468797611403033
Behnen, T.	The man from the biosphere—exploring the interaction between a protected cultural landscape and its residents by quantitative interviews: the case of the UNESCO Biosphere Reserve Rhön, Germany	Eco. Mont, 3(1), 5–10.	2011	http://doi.org/10.1553/eco.mont-3-1s5

Table A1. *Cont.*

Author(s)	Title	Journal, Number (Issue), Pages	Year	DOI
Boja, V., and Popescu, I.	Social ecology in the Danube Delta: theory and practice	Lakes and Reservoirs: Research and Management, 5(2), 125–131	2000	http://doi.org/10.1046/j.1440-1770.2000.00107.x
Brenner, L., and Job, H.	Actor-oriented management of protected areas and ecotourism in Mexico	Journal of Latin American Geography, 5(2), 7–27	2006	http://doi.org/10.1353/lag.2006.0019
Catalán, A. K. R.	The Monarch Butterfly Biosphere Reserve: an exemplary participative approach?	Environmental Development, 16, 90–103.	2015	http://doi.org/10.1016/j.envdev.2015.04.005
Constantin, M.	On the ethnographic categorization of biodiversity in the Danube Delta "Biosphere Reserve"	Eastern European Countryside, 18(1), 49–60	2012	http://doi.org/10.2478/v10130-012-0003-x
Devine, J.	Counterinsurgency ecotourism in Guatemala's Maya Biosphere Reserve	Environment and Planning D: Society and Space, 32(6), 984–1001	2014	http://doi.org/10.1068/d13043p
Durand, L., Figueroa, F., and Trench, T.	Inclusion and exclusion in participation strategies in the Montes Azules Biosphere Reserve, Chiapas, Mexico	Conservation and Society, 12(2), 175–189.	2014	http://doi.org/10.4103/0972-4923.138420
Durand, L., and Lazos, E.	The local perception of tropical deforestation and its relation to conservation policies in Los Tuxtlas Biosphere Reserve, Mexico	Human Ecology, 36(3), 383–394	2008	http://doi.org/10.1007/s10745-008-9172-7
Elgert, L.	Governing portable conservation and development landscapes: reconsidering evidence in the context of the Mbaracayú Biosphere Reserve	Evidence and Policy, 10(2), 205–222	2014	http://doi.org/10.1332/174426514X13990327720607
Fazito, M., Scott, M., and Russell, P.	The dynamics of tourism discourses and policy in Brazil	Annals of Tourism Research, 57, 1–17	2016	http://doi.org/10.1016/j.annals.2015.11.013
Fu, B., Wang, K., Lu, Y., Liu, S., Ma, K., Chen, L., and Liu, G.	Entangling the complexity of protected area management: the case of Wolong Biosphere Reserve, Southwestern China	Environmental Management, 33(6), 788–798	2004	http://doi.org/10.1007/s00267-004-0043-8
Gerritsen, P., and Wiersum, F.	Farmer and conventional perspectives on conservation in Western Mexico	Mountain Research and Development, 25(1), 30–36	2005	http://doi.org/10.1659/0276-4741(2005)025{[}0030:FACPOC{]}2.0.CO;2
Grandia, L.	Raw hides: hegemony and cattle in Guatemala's northern lowlands	Geoforum, 40(5), 720–731	2009	http://doi.org/10.1016/j.geoforum.2009.01.004
Habibah, A., Er, A. C., Mushrifah, I., Hamzah, J., Sivapalan, S., Buang, A., . . . Sharifah Mastura, S. A.	Revitalizing ecotourism for a sustainable Tasik Chini Biosphere Reserve	Asian Social Science, 9(14), 70–85	2013	http://doi.org/10.5539/ass.v9n14p70
Hagan, K., and Williams, S.	Oceans of discourses: utilizing Q methodology for analyzing perceptions on marine biodiversity conservation in the Kogelberg Biosphere Reserve, South Africa	Frontiers in Marine Science, 3, 188.	2016	http://doi.org/10.3389/fmars.2016.00188

Table A1. *Cont.*

Author(s)	Title	Journal, Number (Issue), Pages	Year	DOI
Hahn, T.	Self-organized governance networks for ecosystem management: Who is accountable?	Ecology and Society, 16(2), 18	2011	http://doi.org/10.5751/ES-04043-160218
Hill, W., Byrne, J., and Pegas, F. de V.	The ecotourism-extraction nexus and its implications for the long-term sustainability of protected areas: what is being sustained and who decides?	Journal of Political Ecology, 23(1), 307–327	2016	http://dx.doi.org/10.2458/v23i1.20219
Hill, W., Byrne, J., and Pickering, C.	The 'hollow-middle': why positive community perceptions do not translate into pro-conservation behaviour in El Vizcaíno Biosphere Reserve, Mexico	International Journal of Biodiversity Science, Ecosystem Services and Management, 11(2), 168–183	2015	http://doi.org/10.1080/21513732.2015.1036924
Hoffman, D. M.	Conch, cooperatives, and conflict: conservation and resistance in the Banco Chinchorro Biosphere Reserve	Conservation and Society, 12(2), 120–132	2014	http://doi.org/10.4103/0972-4923.138408
Humer-Gruber, A.	Farmers' perceptions of a mountain biosphere reserve in Austria	Mountain Research and Development, 36(2), 153–161	2016	http://doi.org/10.1659/MRD-JOURNAL-D-15-00054.1
Kent, K., Sinclair, A. J., and Diduck, A.	Stakeholder engagement in sustainable adventure tourism development in the Nanda Devi Biosphere Reserve, India	International Journal of Sustainable Development and World Ecology, 19(1), 89–100	2012	http://doi.org/10.1080/13504509.2011.595544
Knaus, F., Bonnelame, L. K., and Siegrist, D.	The economic impact of labeled regional products: the experience of the UNESCO Biosphere Reserve Entlebuch	Mountain Research and Development, 37(1), 121–130	2017	http://doi.org/10.1659/MRD-JOURNAL-D-16-00067.1
Kraus, F., Merlin, C., and Würzburg, H. J.	Biosphere reserves and their contribution to sustainable development	Zeitschrift Für Wirtschaftsgeographie, 58(2–3), 164–180.	2014	NA
Langholz, J.	Exploring the effects of alternative income opportunities on rainforest use: insights from Guatemala's Maya Biosphere Reserve	Society and Natural Resources, 12(2), 139–149.	1999	http://doi.org/10.1080/089419299279803
Lee, A. E.	Territorialisation, conservation, and neoliberalism in the Tehuacán-Cuicatlán Biosphere Reserve, Mexico	Conservation and Society, 12(2), 147–161	2014	http://doi.org/10.4103/0972-4923.138413
Li, W.	Community decision making—participation in development	Annals of Tourism Research, 33(1), 132–143	2006	http://doi.org/10.1016/j.annals.2005.07.003
Liu, W., Vogt, C. A., Lupi, F., He, G., Ouyang, Z., and Liu, J.	Evolution of tourism in a flagship protected area of China	Journal of Sustainable Tourism, 24(2), 203–226	2016	http://doi.org/10.1080/09669582.2015.1071380
Lu, Y., Fu, B., Chen, L., Xu, J., and Qi, X.	The effectiveness of incentives in protected area management: an empirical analysis	International Journal of Sustainable Development and World Ecology, 13(5), 409–417	2006	http://doi.org/10.1080/13504500609469690

Table A1. *Cont.*

Author(s)	Title	Journal, Number (Issue), Pages	Year	DOI
Lyon, A., Hunter-Jones, P., and Warnaby, G.	Are we any closer to sustainable development? Listening to active stakeholder discourses of tourism development in the Waterberg Biosphere Reserve, South Africa	Tourism Management, 61, 234–247	2017	http://doi.org/10.1016/j.tourman.2017.01.010
Ma, Z., Li, B., Li, W., Han, N., Chen, J., and Watkinson, A. R.	Conflicts between biodiversity conservation and development in a biosphere reserve	Journal of Applied Ecology, 46(3), 527–535	2009	http://doi.org/10.1111/j.1365-2664.2008.01528.x
Mahapatra, A. K., Tewari, D. D., and Baboo, B.	Displacement, deprivation and development: the impact of relocation on income and livelihood of tribes in Similipal Tiger and Biosphere Reserve, India	Environmental Management, 56(2), 420–432	2015	http://doi.org/10.1007/s00267-015-0507-z
Maikhuri, R. K., Nautiyal, S., Rao, K. S., Chandrasekhar, K., Gavali, R., and Saxena, K. G.	Analysis and resolution of protected area-people conflicts in Nanda Devi Biosphere Reserve, India	Environmental Conservation, 27(1), 43–53	2000	http://doi.org/10.1017/S0376892900000060
Martinez-Reyes, J. E.	Beyond nature appropriation: towards post-development conservation in the Maya Forest	Conservation and Society, 12(2), 162–174	2014	http://doi.org/10.4103/0972-4923.138417
Mehring, M., and Stoll-Kleemann, S.	How effective is the buffer zone? Linking institutional processes with satellite images from a case study in the Lore Lindu Forest Biosphere Reserve, Indonesia	Ecology and Society, 16(4), 3	2011	http://doi.org/10.5751/ES-04349-160403
Méndez-Contreras, J., Dickinson, F., and Castillo-Burguete, T.	Community member viewpoints on the Ría Celestún Biosphere Reserve, Yucatan, Mexico: suggestions for improving the community/natural protected area relationship	Human Ecology, 36(1), 111–123	2008	http://doi.org/10.1007/s10745-007-9135-4
Mollett, S.	Está listo (Are you ready)? Gender, race and land registration in the Río Plátano Biosphere Reserve	Gender, Place and Culture, 17(3), 357–375	2010	http://doi.org/10.1080/09663691003737629
Monterroso, I., and Barry, D.	Legitimacy of forest rights: the underpinnings of the forest tenure reform in the protected areas of Petén, Guatemala	Conservation and Society, 10(2), 136–150	2012	http://doi.org/10.4103/0972-4923.97486
Nautiyal, S., and Nidamanuri, R. R.	Conserving biodiversity in protected area of biodiversity hotspot in India: a case study	International Journal of Ecology and Environmental Sciences, 36(2–3), 195–200	2010	NA
Olson, E. A.	Notions of rationality and value production in ecotourism: examples from a Mexican biosphere reserve	Journal of Sustainable Tourism, 20(2), 215–233	2012	http://doi.org/10.1080/09669582.2011.610509
Pfueller, S. L.	Role of bioregionalism in Bookmark Biosphere Reserve, Australia	Environmental Conservation, 35(2), 173–186	2008	http://doi.org/10.1017/S0376892908004839
Pulido, M. T., and Cuevas-Cardona, C.	Cactus nurseries and conservation in a biosphere reserve in Mexico	Ethnobiology Letters, 4, 96–104	2013	http://dx.doi.org/10.14237/ebl.4.2013.58

Table A1. *Cont.*

Author(s)	Title	Journal, Number (Issue), Pages	Year	DOI
Rao, K. S., Nautiyal, S., Maikhuri, R. K., and Saxena, K. G.	Local peoples' knowledge, aptitude and perceptions of planning and management issues in Nanda Devi Biosphere Reserve, India	Environmental Management, 31(2), 168–181	2003	http://doi.org/10.1007/s00267-002-2830-4
Richardson, T.	On the limits of liberalism in participatory environmental governance: conflict and conservation in Ukraine's Danube Delta	Development and Change, 46(3), 415–441	2015	http://doi.org/10.1111/dech.12156
Ruíz-López, D. M., Aragón-Noriega, A. E., Luna-Gonzalez, A., and Gonzalez-Ocampo, H. A.	Applying fuzzy logic to assess human perception in relation to conservation plan efficiency measures within a biosphere reserve	Ambio, 41(5), 467–478	2012	http://doi.org/10.1007/s13280-012-0252-y
Silori, C. S.	Socio-economic and ecological consequences of the ban on adventure tourism in Nanda Devi Biosphere Reserve, western Himalaya	Biodiversity and Conservation, 13(12), 2237–2252	2004	http://doi.org/10.1023/B:BIOC.0000047922.06495.27
Silori, C. S.	Perception of local people towards conservation of forest resources in Nanda Devi Biosphere Reserve, north-western Himalaya, India	Biodiversity and Conservation, 16(1), 211–222	2007	http://doi.org/10.1007/s10531-006-9116-8
Singh, R. B., Mal, S., and Kala, C. P.	Community responses to mountain tourism: a case in Bhyundar Valley, Indian Himalaya	Journal of Mountain Science, 6(4), 394–404	2009	http://doi.org/10.1007/s11629-009-1054-y
Smith, A. N.	Dilemmas of sustainability in Cocopah Territory: an exercise of applied visual anthropology in the Colorado River Delta	Human Organization, 75(2), 129–140	2016	http://doi.org/10.17730/0018-7259-75.2.129
Sodikoff, G.	The low-wage conservationist: biodiversity and perversities of value in Madagascar	American Anthropologist, 111(4), 443–455	2009	http://doi.org/10.1111/j.1548-1433.2009.01154.x
Solberg, M.	Patronage, contextual flexibility, and organisational innovation in Lebanese protected areas management	Conservation and Society, 12(3), 268–279	2014	http://doi.org/10.4103/0972-4923.145138
Steinberg, M., Taylor, M., and Kinney, K.	The El Cielo Biosphere Reserve: forest cover changes and conservation attitudes in an important neotropical region	The Professional Geographer, 66(3), 403–411	2014	http://doi.org/10.1080/00330124.2013.799994
Sundberg, J.	Strategies for authenticity, space, and place in the Maya Biosphere Reserve, Petén, Guatemala	Yearbook. Conference of Latin Americanist Geographers, 24, 85–96	1998	http://doi.org/http://dx.doi.org/10.1108/17506200710779521
Sundberg, J.	Conservation as a site for democratization in Latin America: exploring the contradictions in Guatemala	Canadian Journal of Latin American and Caribbean Studies, 27(53), 73–103	2002	http://doi.org/10.1080/08263663.2002.10816815
Sundberg, J.	Conservation and democratization: constituting citizenship in the Maya Biosphere Reserve, Guatemala	Political Geography, 22(7), 715–740	2003	http://doi.org/10.1016/S0962-6298(03)00076-3

Table A1. *Cont.*

Author(s)	Title	Journal, Number (Issue), Pages	Year	DOI
Sundberg, J.	Identities in the making: conservation, gender and race in the Maya Biosphere Reserve, Guatemala	Gender, Place and Culture, 11(1), 43–66	2004	http://doi.org/10.1080/0966369042000188549
Sundberg, J.	Conservation encounters: transculturation in the "contact zones" of empire	Cultural Geographies, 13(2), 239–265	2006	http://doi.org/10.1191/1474474005eu337oa
Sylvester, O., Segura, A. G., and Davidson-Hunt, I. J.	The protection of forest biodiversity can conflict with food access for indigenous people	Conservation and Society, 14(3), 279–290	2016	http://doi.org/10.4103/0972-4923.191157
Trillo-Santamaría, J.-M., and Paül, V.	Transboundary protected areas as ideal tools? Analyzing the Gerês-Xurés Transboundary Biosphere Reserve	Land Use Policy, 52, 454–463	2016	http://doi.org/10.1016/j.landusepol.2015.12.019
Vaidianu, N., Tofan, L., Braghina, C., and Schvab, A.	Legal and institutional framework for integrated governance in a biosphere reserve	Journal of Environmental Protection and Ecology, 16(3), 1149–1159	2015	NA
Velez, M., Adlerstein, S., and Wondolleck, J.	Fishers' perceptions, facilitating factors and challenges of community-based no-take zones in the Sian Ka'an Biosphere Reserve, Quintana Roo, Mexico	Marine Policy, 45, 171–181	2014	http://doi.org/10.1016/j.marpol.2013.12.003
Xu, J., Chen, L., Lu, Y., and Fu, B.	Local people's perceptions as decision support for protected area management in Wolong Biosphere Reserve, China	Journal of Environmental Management, 78(4), 362–372	2006	http://doi.org/10.1016/j.jenvman.2005.05.003
Young, E.	Local people and conservation in Mexico's El Vizcaino Biosphere Reserve	The Geographical Review, 89(3), 364–390	1999	http://doi.org/10.2307/216156
Yuan, J., Dai, L., and Wang, Q.	State-led ecotourism development and nature conservation: a case study of the Changbai Mountain Biosphere Reserve, China	Ecology and Society, 13(2), 55	2008	http://doi.org/10.5751/ES-02645-130255

Appendix D

Category and sub-category definitions

Table A2. Definition of the main categories related to the management and governance of biosphere reserves (BRs).

Category	Definition
Context (C)	Place-based and multiscale features of which the presence or absence shape the settings where BRs are implemented. They can have a direct or indirect influence in the process, the inputs or the outcomes. The context is not about the BR implementation (process) but about the characteristics of the settings, independently of the BR.
Inputs (I)	What was invested in the process? Material and immaterial support or opposition at different scales.
Process (P)	How is management/governance being conducted? The actions and mechanisms by which management and governance takes place.
Outcomes (O)	Impacts and benefits in social and ecological systems, that followed the implementation of the process.

Table A3. Definition of the sub-categories included in the "Context" category. BR—biosphere reserve.

Sub-Category	Definition
C1 Regulations—formal rules	The written rules, i.e., legislation, regulatory structure, land tenure. This does not mean that they are the rules in use, since actors can ignore them and use informal rules. Legislatures, regulatory agencies and courts usually determine the formal rules in place [69].
C2 Informal institutions and culture	Rules that are self-organized by informal gatherings, appropriation teams or private associations [69]. It also includes norms, i.e., shared perceptions/beliefs among a social group which define the proper or improper behaviors. They are closely related to cultural prescriptions and, therefore, issues related to culture are also included here [30]. Trust-reciprocity/social capital is also associated with existing social norms. Here only the social context is observed—if the use of natural resources is considered to be part of the culture, this is included in the sub-category "Use of natural resources cultural purposes" (C11).
C3 Power issues	Power is related to the "ability to force people to do things they would not independently choose to do" [70]. Power issues are referred to by the term "power" and/or linked with the identification of some group with power (e.g., men) and a group without power (e.g., women), in a defined context.
C4 Organizations	An organization refer to a group of people which are bounded to achieve some common objective, including political bodies, economic bodies, social bodies and education bodies [71]. All aspects related to the organizations in place—organizations structure, inter-organizations relationships, organizations goals, and other organization features, such as if organizations are corrupt, are included here. This includes also factors related to the ability, or lack of ability, of organizations to meet their goals, e.g., lack of funding, human resources or human resources without skills.
C5 Historical factors	Historical factors are events that occurred in the past which still impact how things happen today, e.g., previous communist regime, colonization. If the event is very recent or is still happening, it is included in one of the other context sub-categories (possibly "Socio-economic attributes"—C8).
C6 Time	Do time restrictions influence management? E.g., the need to do something fast; time restrictions influenced the participatory processes.
C7 Economy and politics	The economic and political systems in place—markets, financial crises, regimes (democratic vs. autocratic), political philosophies (liberalism vs. non-liberalism).
C8 Socio-economic attributes	Includes social and economic phenomena such as: (1) social phenomena, i.e. migrations, conflicts; political phenomena, i.e. the fall of a president; illegal activities, i.e. the illegal exploitation of natural resources, human trafficking, drugs, etc.; (2) general attributes of the society: unemployment, poverty, population size, etc.; (3) infrastructure in place—access to water or electricity services (not information infrastructure); (4) specific characteristics of the communities, e.g., level of education, skills, resources.
C9 Information related	Existing communication infrastructure and the quality of information sources, such as media; e.g., if there is access to internet or telephone, or if local media report news about a BR.
C10 Use of natural resources for livelihoods	The exploitation of natural resources is reported to be important for livelihoods; i.e., fishing, logging or subsistence agriculture is fundamental to provide food, shelter or medicinal plants. This requires the extraction of the natural resource.
C11 Use of natural resources for cultural purposes	Natural resources are reported to be important for cultural purposes, e.g., recreation and religion. Includes both extractive and non-extractive use of natural resources for cultural purposes. Therefore, if it is reported that the extractive use of natural resources (e.g., fishing) is part of a community culture, it is also included here.

Table A3. *Cont.*

Sub-Category	Definition
C12 Impacts on natural resources	Includes references of impacts on natural resources, e.g., less fish, pollution, etc.
C13 Human–wildlife conflicts	Conflicts between people and wildlife, e.g., wildlife attacks on livestock or humans.
C14 Cultural landscape	The historical/traditional use of the landscape makes it dependent on these human–nature interactions. This dependency is reported.
C15 Conservationist value	The species or ecosystems in place are reported to have conservationist value, e.g., species are highly endangered or the presence of a unique habitat.
C16 Bio-physical attributes	Bio-physical attributes, such as altitude or climate, including the occurrence of extreme weather events, or ecological disasters such as pests.
C17 Resource mobility	The presence of resources with high mobility which influence management/governance/outcomes, e.g., migratory species.

Table A4. Definition of the sub-categories included in the "Inputs" category. BR—biosphere reserve.

Sub-Category	Definition
I1 Attitudes	According to Ajzen and Fishbei [72] "An attitude can be defined as a positive or negative evaluation of an object or quality". We included manifested attitudes, i.e., the negative or positive evaluations people express about the process, and not behaviors (e.g. because people don't like the management body (attitude), they do not go to the meetings (behavior, in this case, is a lack of non-material support)).
I2 Beliefs	Beliefs underlie "a person's attitudes and subjective norms, and they ultimately determine intentions and behavior" [72]. We are coding beliefs, including perceived benefits or impacts, values and worldviews, which explain why people have a determined attitude or behavior.
I3 Funding and material support/opposition	Includes concrete assistance, such as funding and performing assigned work for others. Opposition do not require active opposition, i.e., when lack of support/funding was reported to have some important effect, it was also included as "passive opposition".
I4 Non-material support/opposition	Includes all forms of support/opposition that are not tangible goods and services, including emotional (caring, empathy, love and trust), informational support (provision of information for problem-solving) and appraisal/affirmational support [73]. We relate the appraisal/affirmational support/opposition with lobbying for or against someone else's cause. Actors can influence process policies in many different ways, including attending and organizing protests or other social movements, participating or not in public meetings on the subject, influencing the media, etc. [74], by facilitating connections between different governmental organizations and influencing decisions. Opposition do not require active opposition, i.e., when lack of support was reported to have some important effect it was also included as "passive opposition".
I5 Type of knowledge	This includes scientific knowledge but also experiential knowledge, i.e., local ecological knowledge, indigenous knowledge and traditional knowledge [7].

Table A5. Definition of the sub-categories included in the "Process" category. BR—biosphere reserve.

Sub-Category	Definition
P1 Process scale	Is the paper about the management/governance of the BR (management/governance body), task/project management/governance, or both?

Table A5. *Cont.*

Sub-Category	Definition
P3 Process initiation	Includes aspects related to how the process was initiated: top-down—the initiative came from the "top" and was imposed in the local settings; participatory—the initiative came from the "top" but its implementation was discussed with local communities since the beginning; bottom-up—self-mobilization of the local communities.
P4 Public participation	Is civil society participating in the BR management/implementation? Includes whether civil society is consulted for BR management and/or projects; participate in BR activities (e.g., as staff) or participate in BR management (e.g., through access to the discussions, dialogue, or influencing BR decisions (adapted from [75,76]).
P5 Participatory processes	Design and organization of participatory meetings, including pre-, during, and post-meeting settings; who is included, balance of power and participatory exclusions [75]. Pre-meeting settings include who participates in the agenda setting, if the information is available to everyone before the meeting and how are invitations to the meeting disseminated; during the meeting settings include how are decisions made, if the information was provided in an adequate format, if there are mechanisms to ensure that everyone has time to speak; post-meeting settings include if there are mechanisms to monitor the implementation of the decisions [51].
P6 Management body	Is there a proper (formal) BR management body in place? What is its degree of centralization? References about the centralization of decision making (e.g., the managers offices are very far away from the BR). What is the structure of the management body—who is included/excluded? How many actors? Power balance.
P7 Coordination and leadership	This includes features related to the quality of the management—bad management is characterized by a lack of functionality, mismanagement and lack of coordination of the activities inside the BR. Its related with lack of collaboration, cooperation, communication and clear mandates for BR management. Characteristics of the decision-makers, such as leadership, are also included.
P8 Institutions for management	This includes the use of formal and/or informal institutions. Formal rules are the written rules, i.e., legislation, regulatory structure, etc. Informal institutions include traditions, customs, beliefs and social networks.
P9 Material investments and infrastructure	This includes the development of infrastructure and acquisition of other tangible materials, such as vehicles.
P10 Human resources related	This includes hiring human resources as staff or managers, and their working conditions—i.e., references to wages, full-time vs. part-time work, seasonality, etc.
P11 Conservation and habitat management	Includes active management of habitats and species in order to achieve conservation goals: habitat restauration through e.g., revegetation, species reintroduction, invasive species control, etc.
P12 Restrictions	Decrease environmental harms through restrictions: prohibitions, restrictions, taxes, fees (e.g., park entry), charges, quotas, compensations for environmental damages (e.g., biodiversity offsets), etc.
P13 Enforcement and control	Enforcement and control of natural resource use and development. Monitoring of activities which harm the environment and sanctioning (e.g., park patrols).
P14 Incentives	Incentives refer to the reduction of environmental harms through the promotion of more environmentally friendly behaviors, e.g., payments for ecosystems services, tax breaks, compensation for wildlife damage, subsidies, forest concessions; promotion of markets for green goods and services by stimulating producers adopting environmentally friendly methods, and consumers buying green goods and services (e.g., certification). It includes all the activities related to sustainable development, such as such as ecotourism, sustainable agriculture, etc.

Table A5. *Cont.*

Sub-Category	Definition
P15 Economic development	This includes the development of initiatives which are mainly related to economic goals, e.g., mining. Fishing and grazing are only considered if some action was made in order to promote these kinds of activities, e.g., revert previous restrictions on natural resource use.
P16 Research and monitoring	Research and monitoring of natural or social resources.
P17 Information and capacity building	This includes: (i) provision of training or consultancy; (ii) development of BR image and platforms with information about the BR or BR policies (website, radio programs, etc.); (iii) information materials, such as flyers and signage; (iv) provision of platforms for dialogue through the organization of participatory meetings and other networking opportunities (such as barbecues, cultural festivals); (v) collaboration, partnerships.
P18 Planning	Planning of processes at different levels (e.g., project or BR; BR management plan). Plans establish the vision, goals and strategies of the process.

Table A6. Definition of the sub-categories included in the "Outcomes" category. BR—biosphere reserve.

Sub-Category	Definition
O1 Economic benefits	Reported increase of monetary wealth or employment; increase of business and industries productivity [77] as a result of management actions.
O2 Social benefits	Improvement of social infrastructure (schools, etc.); increase social capital by an increase of trust, cooperation and better communication; decrease in conflicts.
O3 Empowerment	Less powerful actors gain (or are given) increase control over their "lives and livelihoods"; if local communities are given the responsibility and decision making of management of their own resources [52].
O4 Health benefits	Includes emotional (motivation, feeling of happiness, satisfaction, sense of live security) and other health related benefits.
O5 Learning	If, after some management/governance action (e.g., participatory processes, training, networking), some of the following occur: (i) there is a change in the strategies/actions, goals or governance mechanisms resulting from social interaction—social learning; (ii) there is a change in people's and/or group perceptions or values—transformative communicative learning; (iii) acquisition of knowledge that is task-orientated/problem solving and aim to improve the performance of the current activity—transformative instrumental learning; (iv) knowledge that results from experience/learning-by-doing—experiential learning; (v) if the paper's author report "learning" (adapted from [54]).
O6 Cultural benefits	Enhancement of cultural identity (cultural revitalization), preservation of traditional knowledge, access to livelihoods and recreation opportunities and promotion of traditional practices or customs [77].
O7 Environmental benefits	Environmental benefits including an increase in species populations, recruitment of plants, resilience, decrease in overharvesting natural resources.
O8 Economic impacts	Reported decrease in monetary wealth or increase of unemployment; decrease of business and industry productivity [77] as a result of management/governance actions.
O9 Social impacts	Displacement; decreased social capital—lack of trust, communication and cooperation; occurrence of conflicts as a result of management/governance actions.
O10 Inequality	Uneven distribution of the benefits and costs of BR management/governance actions.
O11 Health impacts	Includes emotional (stress, frustration, dissatisfaction, insecurity) and other health-related impacts resulting from management/governance actions.

Table A6. *Cont.*

Sub-Category	Definition
O12 Cultural impacts	Impacts of cultural identity, e.g., by separating people from their traditional livelihoods or culturally important sites and resources, erosion of traditional knowledge and other traditional practices or customs [77].
O13 Environmental impacts	Environmental impacts including decreases in species population or distribution, overharvesting natural resources or decreases in resilience as a result of management/governance actions.

Appendix E

Demonstration of how the components of the proposed framework can interact with each other. The figure is illustrative of some relationships between factors found in the study of Lyon and his collegues [45]. Feedback between factors within the same category were omitted for better visualization of interactions between the different categories.

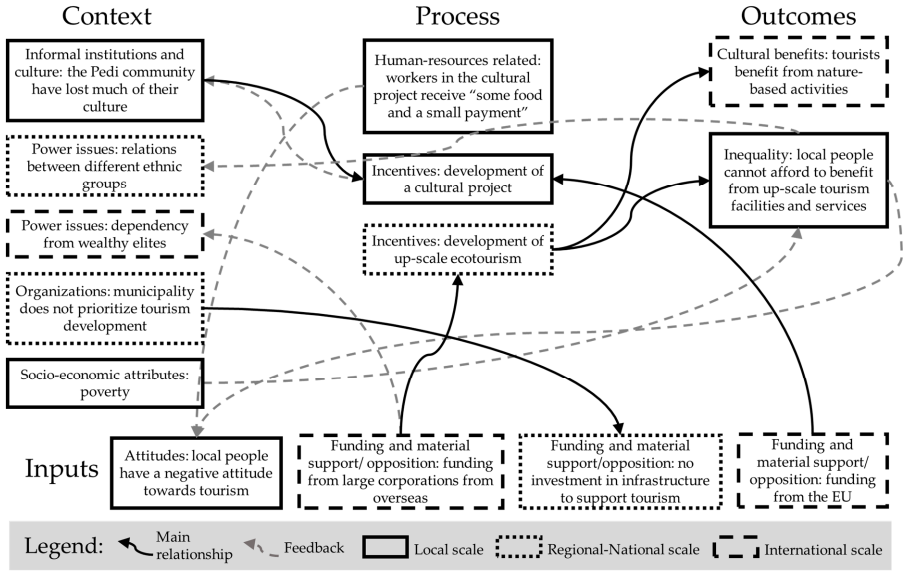

Figure A2. Demonstration of how the components of the framework interact with each other through the presentation of some features of the study of Lyon and his collegues [45].

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