ARLAN JACK CORONEL TORO

MANAGEMENT EFFECTIVENESS IN NATIONAL PARKS FROM PERU

Dissertation submitted to the Forest Science Graduate Program of the Universidade Federal de Viçosa in partial fulfillment of the requirements for the degree of *Magister Scientiae.*

Adviser: Alexandre Simões Lorenzon

Co-advisers: Gumercindo Souza Lima
Écio Souza Diniz

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APPROVED: August 27, 2021.

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Dedicated "To my grandfather Grimaldo Alfonso Coronel Guzman (in memoriam), the greatest example of a human being with integrity and ethics".

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ABSTRACT

Toro, Arlan Jack Coronel, M.Sc., Universidade Federal de Viçosa, August, 2021. **Management effectiveness in national parks from Peru**. Adviser: Alexandre Simões Lorenzon. Co-advisers: Gumercindo Souza Lima and Écio Souza Diniz.

The unsustainable exploitation of natural resources in protected areas has increased globally and at an accelerated rate in the 21st century, mainly in tropical regions such as South America. This scenario has worried the scientific community, due to the risks of loss of biodiversity and ecosystem functions, while at the same time there is a growing urgency for the inspection and maintenance of these areas. In this context, the central objective of this work was to evaluate the management effectiveness of national parks in Peru. For this, the scenario matrix was used, which is based on the application of a questionnaire to park managers. The methodology establishes possible scenarios based on a set of indicators, thus generating the result of park management effectiveness (unsatisfactory to satisfactory). Most parks (6 or 55%) showed medium management effectiveness and 45% (5 parks) of the parks showed satisfactory management effectiveness. The effectiveness found is explained by the positive performance of the indicators expropriation, relationship with the surroundings, protection and inspection programs, and management plan. Also, there is no significant difference in the importance of the indicators for the final answers on the effectiveness of park management. Our results indicate that Peru's national parks are currently well managed. However, some indicators need to be improved, especially for parks that showed medium management effectiveness. Furthermore, this study can help managers to maintain and allocate financial resources in protected areas with greater precision, since the scenario matrix methodology allows the identification of low performance indicators.

Keywords: Protected natural areas. Scenario matrix. Performance indicators.

RESUMO

Toro, Arlan Jack Coronel, M.Sc., Universidade Federal de Viçosa, agosto de 2021. **Avaliação da efetividade de manejo dos parques nacionais do Peru**. Orientador: Alexandre Simões Lorenzon. Coorientadores: Gumercindo Souza Lima e Écio Souza Diniz.

A exploração não sustentável de recursos naturais em áreas protegidas tem aumentado globalmente e de forma acelerada no século 21, principalmente em regiões tropicais como a América do Sul. Esse cenário tem preocupado a comunidade científica, devido aos riscos de perda de biodiversidade e funções ecossistêmicas, ao mesmo tempo em que cresce a urgência por fiscalização e manutenção dessas áreas. Nesse contexto, este trabalho teve como objetivo central avaliar a efetividade de manejo dos parques nacionais do Peru. Para tal, utilizou-se a matriz de cenários, que é baseada na aplicação de questionário aos gestores dos parques. A metodologia estabelece cenários possíveis a partir de um conjunto de indicadores gerando, assim, o resultado de efetividade do manejo do parque (insatisfatório a satisfatório). A maioria dos parques (6 ou 55%) apresentaram efetividade de manejo médio e 45% (5 parques) dos parques apresentaram efetividade de manejo satisfatório. As efetividades encontradas são explicadas pelo desempenho positivos dos indicadores desapropriação, relação com o entorno, programas de proteção e fiscalização e plano de manejo. Além disso, não há diferença significativa na importância dos indicadores para as respostas finais sobre a efetividade de manejo dos parques. Nossos resultados indicam que atualmente os parques nacionais do Peru estão bem manejados. Contudo, alguns indicadores precisam ser melhorados, principalmente para os parques que apresentaram efetividade de manejo médio. Ademais, este estudo pode auxiliar os gestores a manter e alocar com maior precisão os recursos financeiros em áreas protegidas, uma vez que a metodologia de matriz de cenários permite identificar os indicadores de baixo desempenho.

Palavras-chave: Áreas naturais protegidas. Matriz de cenários. Indicadores de desempenho.

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SUMMARY

1. INTRODUCTION

In the first decades of the 21st century, the expansion without suitable management or regulation of anthropic activities, such as agriculture, mining and urbanization (DE LIMA FILHO et al., 2021; GIGER; ECKERT; LAY, 2021; PLATTO et al., 2021), contributed to major impacts on natural environments. Consequences include forest fragmentation, climate change, loss of biodiversity and ecosystem functions, as well as the emergence of new zoonotic diseases (BOZZUTO; CANESSA; KOELLA, 2021; TAJUDEEN et al., 2021; TERRAUBE; FERNÁNDEZ-LLAMAZARES, 2020). To avoid inappropriate and widespread use of natural resources, protected areas have been created around the world.

The increase of illegal extraction in protected areas has intensified habitat fragmentation, leading to biodiversity loss and severe alterations in ecosystem services, which affects human quality of life due to the interconnected chain of ecological processes (BANKS-LEITE et al., 2020; PÜTTKER et al., 2020). However, this fragmentation also provides an opportunity to intensify and maintain the proper management of protected areas, safeguarding the benefits of their ecological integrity, financial return from sustainable exploration and social relevance for local communities (SYNES et al., 2020; WAITHAKA et al., 2021). In the other hand, the emergence of global crises, such as COVID-19 pandemic, challenge the management and monitoring of protected areas (BATES; PRIMACK; DUARTE, 2021; HOCKINGS et al., 2020; SMITH et al., 2021). The main difficult arises from the significant reduction in partnerships, research, project and public policies aiming management plans or the proper use of natural resources from protected areas (CORLETT et al., 2020; SEVERO; DE GUIMARÃES; DELLARMELIN, 2021).

The creation of protected areas has fostered the highest levels of ecosystem conservation (GRAY et al., 2016; JONES et al., 2018; RIVAROLA; SIMBERLOFF; LEPPANEN, 2019). Among their objectives, clauses I to VI from the International Union for Conservation of Nature (IUCN) indicate forms of management ranging from strict biodiversity conservation to sustainable human exploration and extraction of natural resources (DUDLEY, 2008). They are also considered strategic for implementing major environmental agreements, such as those proposed in the Convention on Biological Diversity (CBD) for 2010 and the Aichi targets for 2020 and post-2020 (VISCONTI et al., 2019). Those agreements comply with the United Nations (UN) 15th goal, whose purpose is the protection and restoration of terrestrial ecosystems, sustainable forest management and reduction of biodiversity loss (UN, 2015).

On a global scale, 22.5 million km2 (16.64%) of land and inland water ecosystems as well as 28.1 million km2 (7.74%) of coastal and ocean waters are embedded within protected and conserved areas according to Protected Planet Report 2020 by UN Environment Program World Conservation Monitoring Centre (UNEP-WCMC) and International Union for Conservation of Nature (IUCN), prepared with National Geographic Society aid (UNEP-WCMC; IUCN, 2021). Those values are corroborated by a global estimate, so that from the 2.8% of the terrestrial ecosystems without anthropic intervention, 11% are part of protected areas (categories I-IV) (PLUMPTRE et al., 2021).

Peru hosts 75 protected areas, managed and administered by the National Service of State-Protected Natural Areas (SERNANP), the regulatory body of the National System of State-Protected Natural Areas (SINANPE), which cover 22,591,259.73 ha (17.3% of the national territory), surpassing Aichi targets (MERCADO et al., 2020). Furthermore, Peru is the ninth country in the world with the largest forest area, the fourth in tropical forest areas and the second largest country in the Amazonian, only behind Brazil (MINAM; VMDERN; PNCB, 2021). With the wide supply of resources present in its natural areas, the Peruvian natural ecosystems are exposed to growing anthropic interventions. Despite a global growth in the coverage of protected areas trigged by the global target of the last decade (COAD et al., 2015), the continuous loss of biodiversity still one of the most important factors associated with low protection and management performance of these areas (UNEP-WCMC, 2017).

The effectiveness evaluation of management for protected areas is an important tool for implementing public policies related to protection and conservation of natural resources. This type of assessment fosters sustainable economic development by mediating conflicts of interest in the use of natural resources, increase of social inclusion and planning the occupation of the habitable territory (MASULLO; GURGEL; LAQUES, 2019). Currently, assessments on management effectiveness have been conducted across 18.29% of the area covered by protected areas in the world, which is below the 60% target set by Parties to the Convention on Biological Diversity (CBD) (UNEP-WCMC; IUCN, 2021).

Since 1990, a variety of tools for assessing management effectiveness in protected areas have been developed around the world, built accordingly IUCN World Commission on Protected Areas (WCPA) framework (HOCKINGS et al., 2006; UNEP-WCMC, 2017). The framework varies in scope and content, ranging from data collection and financial inputs, based on qualitative data questionnaires, e.g., expert opinion or managerial experience, to more complex empirical assessments, e.g., long-term monitoring, land degradation impacts and

carbon stock levels (ARARUNA; SOARES, 2017; HOCKINGS et al., 2006). However, comprehensive evaluations of management effectiveness may require considerable time and financial resources (ÁLVAREZ MALVIDO et al., 2021; COAD et al., 2015; LEVERINGTON et al., 2010).

The management of protected areas both in Peru and South America is one of the most complex activities, in which cultural, environmental and social factors are important elements for implementing and executing effective management, which have the potential to integrate society and nature protection (ÁLVAREZ MALVIDO et al., 2021; CARDOSO et al., 2020; DOVERS et al., 2021; RAIMUNDO, 2019). In this context, the main aim of this study was to evaluate the effectiveness of management of national parks in Peru, in order to provide information that allows decision makers direct efforts and investments for proper conservation of these parks.

2. MATERIALS AND METHODS

2.1. Study áreas

The study areas correspond to the national parks of Peru (Figure 1). National parks are large natural spaces and the category best known for being the pioneers in the care of protected natural spaces on the planet (NOÉ HERNÁNDEZ et al., 2018). In Peru, parks are considered areas of national administration and indirect use; where research, recreation and tourism are allowed, but not the extraction of natural resources (SOLANO, 2009; TOVAR; GUERRERO FORERO, 2011). Since 1961, a total of fifteen national parks have been established in various natural regions of the country (Table 1), which add up to a total area of 10,394,366.70 ha (SERNANP; INEI, 2020). Deforestation and forest degradation in Peru is mainly caused by agriculture, commercial mining (e.g., gold and iron), oil and gas extraction, cattle ranching, road construction, and timber extraction (HUANCA et al., 2020; MINAM, 2016; SMITH JULIAN; SCHWARTZ JILL, 2015). The permanence of national parks must be assured in the long term, without altering ecological processes or ecosystem functions (SOLANO, 2020).

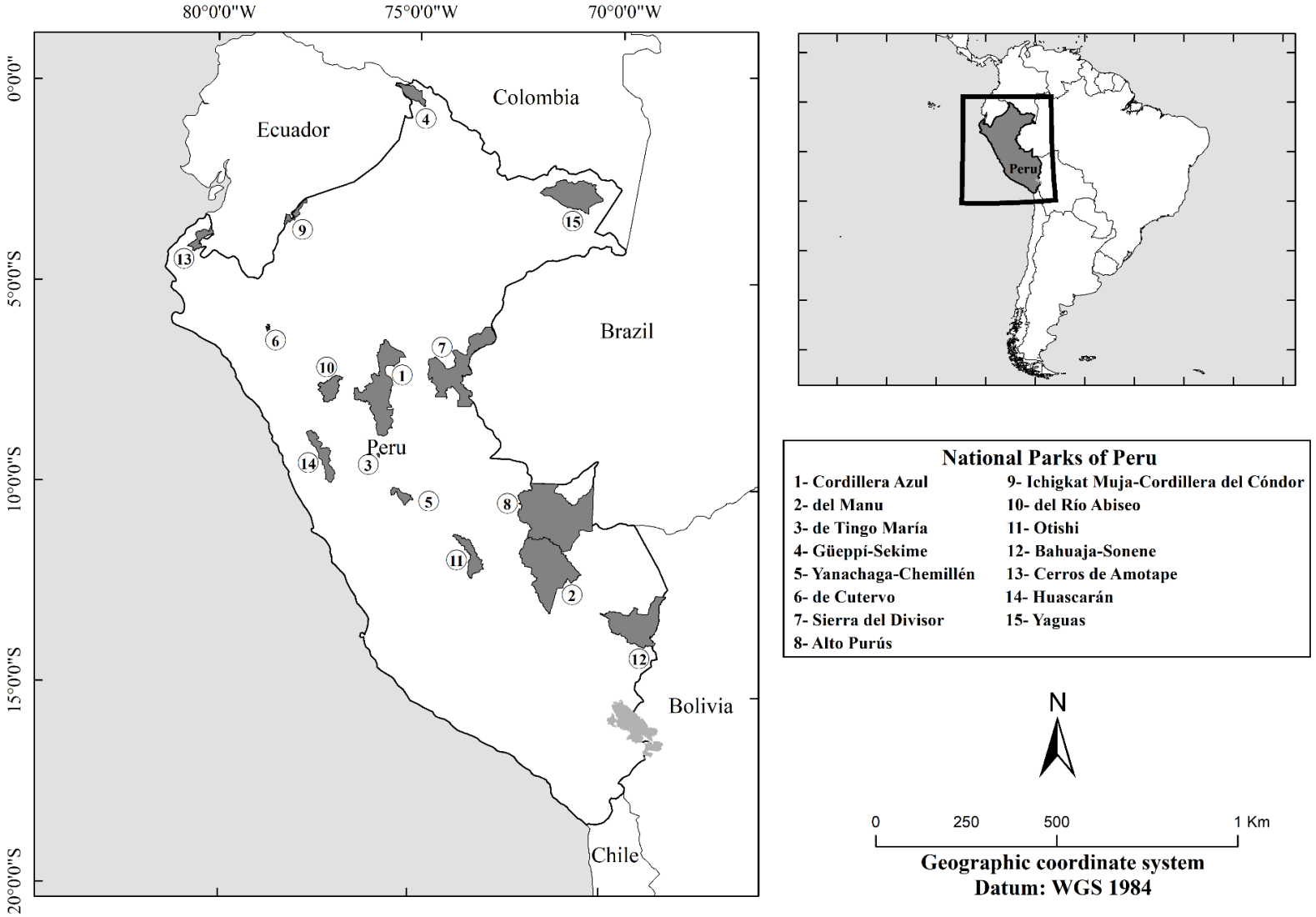

Figure 1 - Location of National Parks in Peru.

Table 1 - Study sites and description of national parks in Peru.

National Park	Location (state)	Creation (year)	Extension (ha)	Altitude (m)	Climate	Precipitation (mm)	Temperature (°C)
N. P. Cutervo	CAJ	1961	8,214,23	1,550 to 3,500	usf	780	12 to 19
N. P. Tingo María	HUC	1965	4,777,00	800 to 3,600	umc	3,300	24.5
N. P. del Manu	CUS and MDD	1973	1,716.295,22	150 to 4,020	mc	1,500 to 8,000	8 to 25.6
N. P. Huascarán	ANC	1975	340,000,00	3,800 to 6,701	sf	250 to 1,400	0 to 7
N. P. Cerros de Amotape	TUM and PIU	1975	151,767,49	120 to 1,538	suc	500 to 1.450	23 to 26
N. P. del Río Abiseo	SAM	1983	274,520,00	350 to 4,200	camu	750 to 2,000	7 to 25
N. P. Yanachaga - Chemillén	PAS	1986	122,000,00	460 to 3,643	cau	1,500 to 6,000	13 to 26
N. P. Bahuaja - Sonene	MDD and PUN	1996	1,091,416,00	500 to 2,450	uc	2,400	8 to 30
N. P. Cordillera Azul	SAM, LOR, UCA and HUC	2001	1,353,190,85	200 to 2,400	cautc	3,000 to 6,000	16 to 27
N. P. Otishi	JUN and CUS	2003	305,973,05	750 to 4,185	v	3,000 to 5,000	25
N. P. Alto Purús	UCA and MDD	2004	2,510,694,41	208 to 2,878	uc	1,800	25
N. P. Ichigkat Muja - Cordillera del Cóndor	AMA	2007	88,477,00	500 to 3,000	tru	2,400 to 4,500	24
N. P. Güeppí-Sekime	LOR	2012	203,628,51	220 to 400	cau	2,800	24.7
N. P. Sierra del Divisor	LOR and UCA	2015	1,354.485,10	200 to 900	cau	1,600 to 2,000	25
N. P. Yaguas	LOR	2018	868,927,84	63 to 246	tru	2,500 to 3,500	21.5 to 27

States (CAJ, Cajamarca; HUC, Huánuco; CUS, Cusco; MDD, Madre de Dios; ANC, Ancash; TUM, Tumbes; PIU, Piura; SAM, San Martín; PAS, Pasco; PUN, Puno; LOR, Loreto; UCA, Ucayali; JUN, Junín; AMA, Amazonas); Climate (usf, humid and semi-cold; umc, humid and very rainy; mc, very rainy; sf, dry and cold; suc, dry, humid and rainy; camu, warm and very humid; cau, warm and humid; uc, humid and rainy; cautc, warm, humid, temperate and rainy; v, varied; tru, tropical and humid) ; Precipitation, medium annual precipitation; Temperature, medium annual temperature (SERNANP, 2016, 2021; SOLANO, 2020).

2.2. Data collection and processing

A proper evaluation and monitoring of management effectiveness needs a flexible, low-cost and fast application methodology for different locations, capable of providing conclusive information to allow decision makers direct efforts and investments for proper conservation of protected areas (SCHULZE et al., 2018). However, commonly used methodologies to assess management effectiveness are not always replicable or comparable for different scenarios (COAD et al., 2015; GONÇALVES; PARREIRA; NABOUT, 2021).

The questionnaires with the Scenario Matrix methodology (LIMA; RIBEIRO; GONÇALVES, 2005) function as a dynamic model of reality, with scenario responses from the worst to the best expected situation in each of the management indicators chosen. This allows managers to provide objective and impartial responses, resulting in more transparent information.

Our data was generated by applying questionnaires to the managers of 11 out of 15 national parks in Peru, following the Scenario Matrix evaluation methodology proposed by Lima et al. (2005) which provides for confirmation based on bibliography and data checking. The questionnaires (Appendix) have a qualitative, descriptive and exploratory nature, in addition of presenting some management indicators. The lack of responses concerning the remaining four parks that were not included in our collection is justified by the temporary absence of their managers, together with other communication problems arising from the pandemic scenario.

To determine the effectiveness level concerning implementation and execution of the management, the following steps were established:

a) Indicator selection: establishes indicators to be used in the management evaluation, which will be directly related to management objectives. The indicators are 11: Demarcation, Expropriation, Human Resources, Infrastructure, Relationship with Surroundings, Partnerships, Financial Resources, Protection and Inspection Programs, Fire Control, Management Plan and Research.

b) Scenario construction: scenarios correspond to instruments commonly used in strategic planning, resulting from the selective articulation of options that work as a dynamic reality model, with the objective of predict the future and foresee possible results. The scenarios in this research range from the worst to best expectations for each of the chosen management indicators.

c) Indicator evaluation: indicators were rated based on scenarios using a scale from

1 to 5. The highest value (5) corresponds to the best situation (optimum), while the lowest value (1) indicates the worst situation (which completely conflicts with the effective management of the protected area).

d) Determination of management effectiveness: established by the obtained scores in each response for each indicator (Table 2). Next, the average of the obtained scores in each answer for each indicator in each national park was extracted, in order to represent the level of management effectiveness (Table 3 and Eq. (1)).

Eq. (1): $$\bar{x} = \frac{p_1 + p_2 + \ldots + p_{11}}{n}$$

$\bar{x}$ = Score obtained for the result by management effectiveness level (Table 3); p = Answer for the score obtained for each indicator (Table 2); n = Number of indicators.

Table 2 - Criteria for defining effectiveness levels.

Answer	Score obtained for each indicator
1	0
2	2.5
3	5.0
4	7.5
5	10

Table 3 - Criteria for analyzing effectiveness levels.

Obtained Score	Effectiveness Level Description
< 2.5	Unsatisfactory effectiveness
2.5-5.0	Low satisfactory effectiveness
5.1-7.5	Medium satisfactory effectiveness
7.6-10.0	Satisfactory effectiveness

2.3. Data analysis

To verify the similarity between parks regarding the considered indicators for management effectiveness, a hierarchical grouping analysis was used (Hierarchical clustering). To perform this analysis, we first computed a matrix of distance between parks based on values of the 11 indicators using the "*dist*" function of R programing language (version 4.0.3) (R DEVELOPMENT CORE TEAM, 2021), specifying "*Euclidean distance*" as the method for distance calculation between groups (BORG; GROENEN, 1997).

Then, the clustering was analyzed with the "*hclust*" function of R programing language (version 4.0.3), using the "average" method (Average Aglomerative Cluster). The selected method generates dendrograms that represent a series of nested groups from which average clustering distances are calculated, with the link between them promoted by UPGMA (group of unweighted pairs with arithmetic mean) (BORCARD; GILLET; LEGENDRE, 2011; EVERITT; HOTHORN, 2011).

In this cluster analysis, the distance that joins two objects (parks) into a group on the dendrogram is called the cophenetic distance. Thus, the results of hierarchical clustering using the "*hclust*" function can be visualized and interpreted based on the height (Height) of group formation, in which, the greater the height, the more separated/dissimilar the groups.

To statistically assess whether any of the indicators significantly influenced the final response of effectiveness (e.g., medium, satisfactory) a Chi-square (χ^2) independence test was used. If the overall value of χ^2 is significant, then a χ^2 partition is performed to assess at which specific level the indicator significantly influences the effectiveness response. The χ^2 independence test is a suitable statistical test for this type of analysis, as it is applied in the evaluation of categorical data to assess how likely any observed difference in the relationship between rows and columns is due chance (AGRESTI, 2007; MANGIAFICO, 2016; PLACKETT, 1983). Thus, the independence test evaluates whether unpaired observations of two categorical variables, expressed in a contingency table, are independent from each other (BOCK; VELLEMAN; VEAUX, 2007; COHEN, 1988). Chi-square analysis was conducted in R programming language, version 4.0.3, using the "*chisq.test*" function.

3. RESULTS

From the 11 analyzed national parks, 6 (55%) presented a medium level of effectiveness, while the remaining 5 (45%) achieved a satisfactory level of effectiveness for their management (Figure 2 and Table 4).

In the evaluation, some parks presented the following cases: perimeter not fully demarcated (2 national parks), never had any partnership with other institutions (4 national parks), no fire protection or control program (1 national park) and no research being developed (1 national park).

Among all national parks assessed in Table 4, National Park Gueppí-Sekime presented the highest score concerning satisfactory management effectiveness. National Park Ichigkat Muja - Cordillera del Cóndor, in turn, presented the lowest score, which indicates its medium management effectiveness.

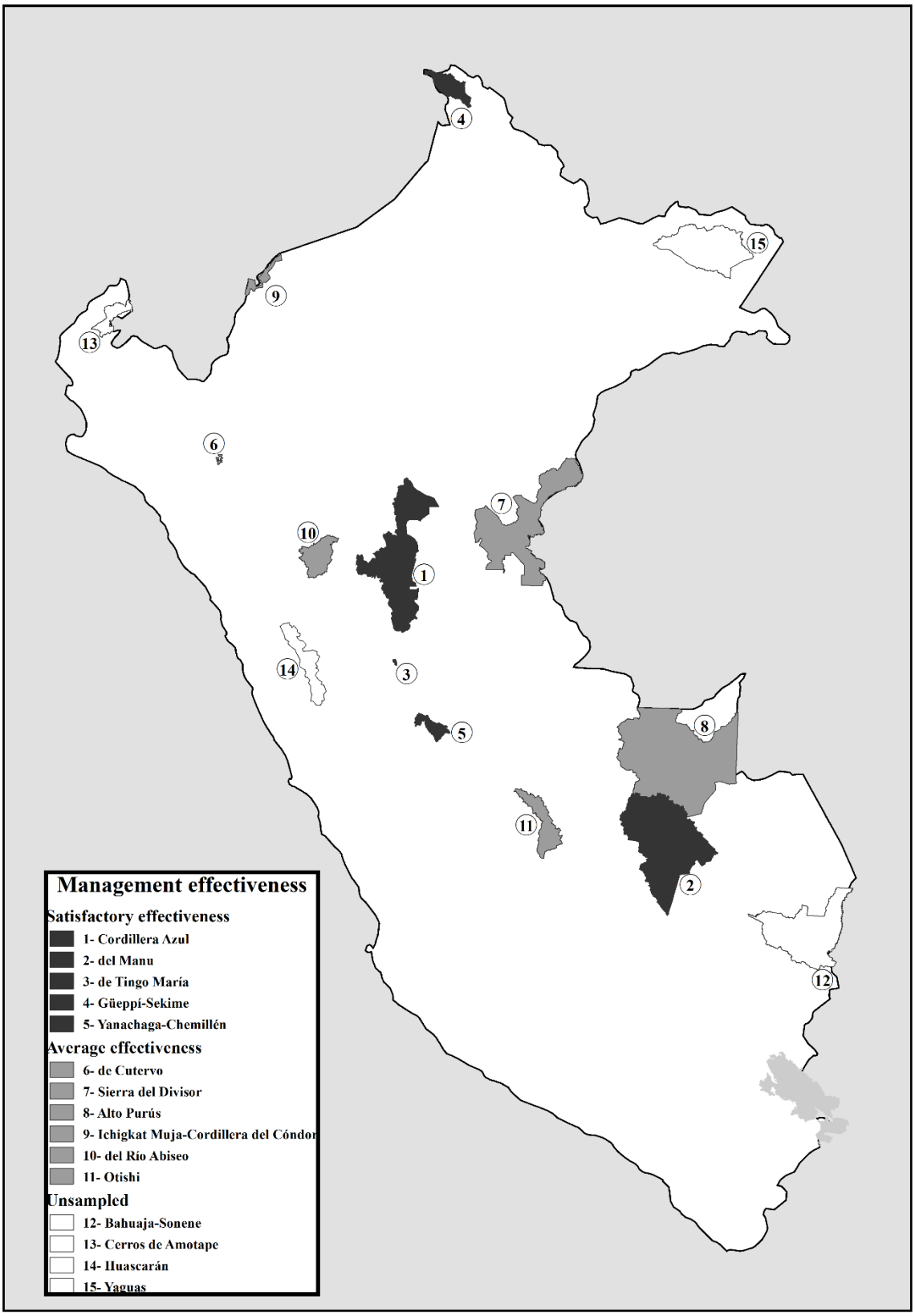

Figure 2 - Management effectiveness of National Parks in Peru.

Table 4 - Evaluation of the National Parks of Peru in relation to 11 indicators of management effectiveness.

National Parks	Dema-rcation	Expro-priation	Human Resources	Infras-tructure	Relationship with surrounding	Partn-ership	Financial Resources	Protection and Inspection	Fire Control	Plan	Rese-arch	Sco-re	Management Effectiveness
N. P. Cutervo	1	4	3	3	3	4	3	5	4	5	5	6.59	Medium
N. P. Cordillera Azul	4	5	4	4	5	5	5	5	4	5	5	9.09	Satisfactory
N. P. Sierra del Divisor	5	5	3	4	5	1	4	5	4	4	1	6.82	Medium
N. P. Alto Purús	3	5	3	2	5	1	4	5	3	5	3	6.36	Medium
N. P. Ichigkat Muja-Cordillera del Cóndor	1	5	3	2	5	1	2	5	1	5	3	5.0	Medium
N. P. del Río Abiseo	3	5	3	4	5	3	2	5	3	5	4	7.04	Medium
N. P. del Manu	5	5	5	5	5	1	5	5	5	5	5	9.09	Satisfactory
N. P. Otishi	2	5	5	2	5	3	3	5	5	4	5	7.50	Medium
N. P. Tingo María	5	5	5	5	5	3	3	5	5	5	5	9.09	Satisfactory
N. P. Güeppí-Sekime	3	5	4	5	5	5	5	5	5	5	5	9.32	Satisfactory
N. P. Yanachaga Chemillén	3	5	3	4	5	4	5	5	5	5	4	8.41	Satisfactory

The cluster analysis (Figure 3) showed the formation of three large groups with closer similarities regarding the indicators of management effectiveness. The first large group was formed by Ichigkat Muja, Alto Purús and Sierra del Divisor. The second large group was formed by Tingo María, Manu, Güeppí-Sekime, Cordillera Azul and Yanachaga Chemillén, while the third group was formed by Río Abiseo, Cutervo and Otishi. Overall, the most similar parks were Gueppí Sekime and Cordilheira Azul, whereas the most distinct were the ones composing the first large group.

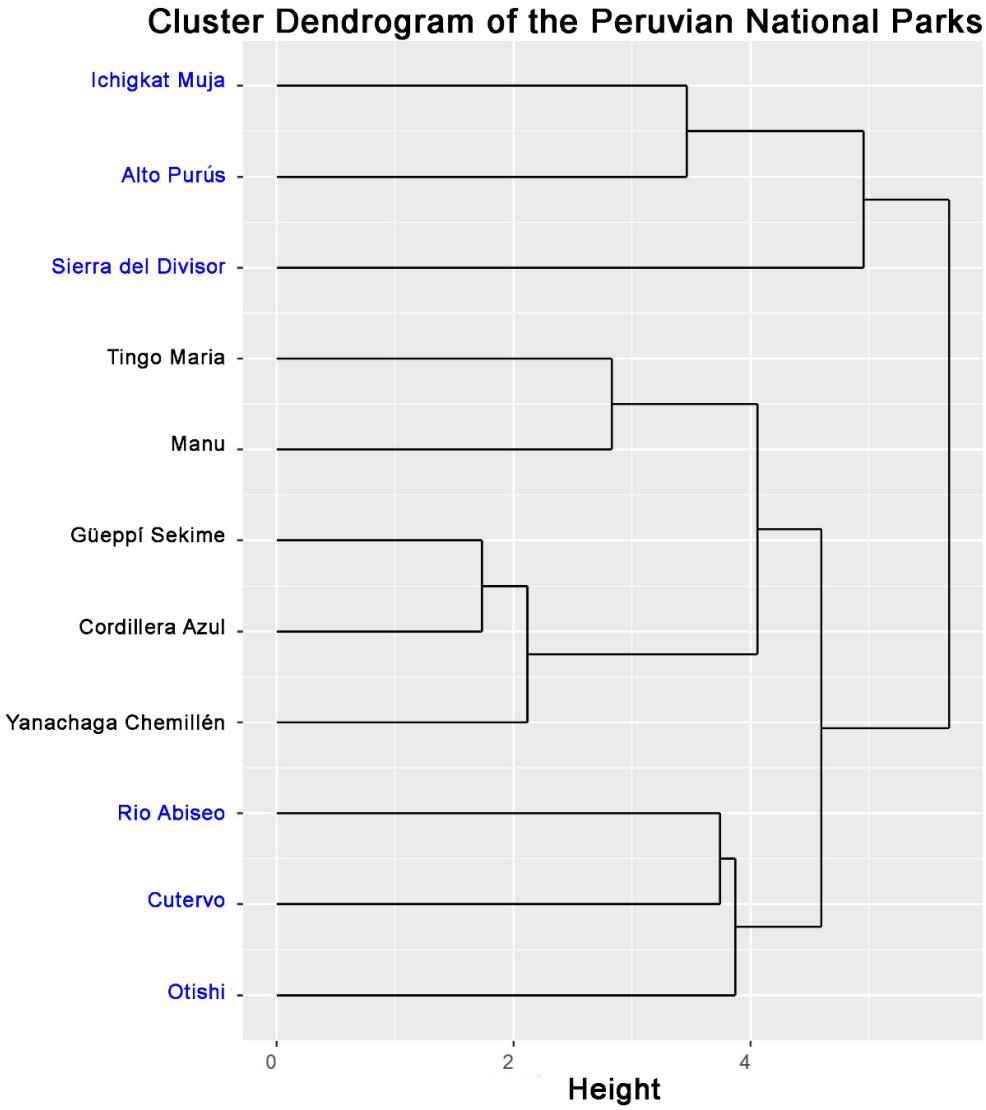

Figure 3 - Dendrogram showing the grouping of national parks based on the indicators score. Blue color = medium management effectiveness; Black color = satisfactory management effectiveness.

Chi-square analysis showed that the 11 indicators considered for parks evaluation do not significantly influence ($\chi^2 = 27.801$, $p > 0.05$) the final response of effectiveness (e.g., medium or satisfactory).

4. DISCUSSION

The effectiveness evaluations showed positive results (55% medium and 45% satisfactory) indicating that national parks in Peru have been managed in accordance with necessary means for the application of an efficient management. This shows that Peruvian parks management have significantly met current demands in the global context of conservation and protection of natural areas such as the post-2020 biodiversity targets that aim to reduce forest degradation and fragmentation, as well as the adoption of political and institutional strategies at different geographic scales (SCHLEICHER; PERES; LEADER-WILLIAMS, 2019). Moreover, it indicates the capacity to meet future demands for natural resource exploration without compromising them. In our study the indicators expropriation, relationship with Surroundings, protection and inspection programs and management plan accounted for the higher evaluation rankings (Table 4) and corresponded to key elements for evaluating the effectiveness of Peru's national parks.

Protected natural areas are land-planning instrument that seeks to guide the best use of the territory and the allocation of property rights (PAREDES-LEGUIZAMÓN, 2019). The indicators of land demarcation and expropriation are basic premises to begin the process of implementing protected areas in Peru, meaning that their boundaries are clearly established by legal instrument (CALLE HAYEN, 2014). The Cutervo and Ichigkat Muja-Cordillera del Condor national parks present conflicts with their limits (table 4), when the Cutervo national park was created in 1961, there was no internal rule that defined what a National Park was, much of its surface suffered the invasion of cattle ranchers and loggers, partly protected by the inaccessibility of the place (SÁNCHEZ RECUAY; CALDERÓN RODRÍGUEZ, 2010), and the Ichigkat Muja-Cordillera del Condor National Park is categorized as a 'Recovery Zone' due to the historical damage of selective logging, hunting and three conflicts regional disputes between Peru and Ecuador as in 1997 (SCULLION et al., 2021).

The 1993 Political Constitution of Peru was the basis for the legal framework of the 1997 Law on Natural Protected Areas, for greater precision regarding the legal effects of natural protected areas on property rights. In January 2000, Supreme Decree 001-2000- AG was passed, stipulating that the National Institute of Natural Resources - INRENA should manage the registration of protected natural areas as national heritage before the Public Registries. Finally, the Protected Natural Areas Law of 2001 reaffirmed that the exercise of property rights prior to the creation of a protected natural area must be compatible with its

character as a national heritage (MONTEFERRI BRUNO, 2016; SOLANO, 2009).

Unlike other countries in Latin America (ANAYA; ESPÍRITO-SANTO, 2018; CLEMENTE MACHADO et al., 2017; CORREIA, 2019; HOLLAND et al., 2017; VÁZQUEZ-VILLA et al., 2020; VILLARREAL; ECHART, 2018), peruvian national parks were created in uninhabited areas or areas of low anthropic activity, which explains the absence of conflicts between the local community and the parks. In addition, the Peruvian national parks (Table 4) have contributed significantly to the development of the surroundings and count on their effective participation in the management of the areas. Further it should be also noted that all parks are open to tourism, which strengthens the relationship with the surrounding community. Therefore, tourism is an important strategy for conservation, recreation, and education, and promotes the sustainable development of local populations (FIGUEROA PINEDO, 2018; MERCADO et al., 2020).

The regulatory body of Protected Natural Areas in Peru SERNANP (National Service of State Protected Natural Areas), is responsible for approving and regulating the management plans of these areas. In addition, SERNANP defines that the management plans of the parks must be reviewed and updated every five years (MINAM; VMDERN; PNCB, 2021; SILVA ROMERO; KUROIWA, 2015). Thus, some Peruvian national parks did not receive maximum marks in the management plan indicator because the plans are in the process of updating (Table 4). The national management plan has been fundamental for this updating and evolution of the parks management, since it comprises a crucial tool for monitoring, evaluating and planning protected areas in the country, once it stipulates and directs the lines of action as well as conservation commitments that must be followed in these areas (SERNANP, 2016; SOLANO, 2020).

Worldwide, the countries have established protected areas and invested resources for their proper management (BORRINI-FEYERABEND et al., 2014). Peru and the countries of Latin America have not been an exception to this process and have a large number of protected areas that cover a significant part of the continent's surface. However, the management of protected areas in Latin America face significant limitations imposed by factors like short financial resources for effective management; lack of qualified personnel; poor infrastructure and equipment for fire control programs, where they exist; imprecise regularization of land ownership in protected areas; scarcity or inaccuracy of management plans and low quality of most of them (ÁLVAREZ MALVIDO et al., 2021; AXIMOFF; MENNA BARRETO; KURTZ, 2020; ELBERS, 2011; NÁJERA DÍAZ, 2019; VARGAS-SANABRIA; CAMPOS-

VARGAS, 2018). In consequence, many protected areas are under increasing risk of substantial loss of the biodiversity they shelter (DOUROJEANNI, 2021; DOUROJEANNI; QUIROGA, 2006). Although all Peruvian national parks (Table 4) had medium or satisfactory management effectiveness, some parks showed low performance for some indicators, such as boundary demarcation, partnerships with other institutions (e.g., NGOs, research institutions), fire protection or control program, scientific research, fundraising, infrastructure and qualified professionals. These indicators, require improvement for a more effective management from protected areas in Peru, which is also true for other countries (DOUROJEANNI, 2018; HERINGER et al., 2020; LIÉVANO-LATORRE; BRUM; LOYOLA, 2021; LÓPEZ-RODRÍGUEZ et al., 2017; OLIVEIRA et al., 2021; POWLEN; GAVIN; JONES, 2021; SCULLION et al., 2021; SINASSON S. et al., 2021).

In Brazil, a study found that increasing investment in order to achieve a more homogeneous geographical distribution of scientific production in protected areas can contribute to future studies, thus increasing the general understanding of the effectiveness of their management (GONÇALVES; PARREIRA; NABOUT, 2021). Already Feng et al. (2021) showed that in China the strengthening of funding, human resources and scientific research play a vital role alongside infrastructure and monitoring for successful management in protected areas. These investments also represent measures that would help to reduce deforestation caused by several sources, such as forest fires, natural phenomena and illegal logging (FENG et al., 2021). For regions like Peru and South-America as a whole, since o the needed resources for maintaining and improving management in protected areas are scarce, the identification of low performance indicators can help managers to optimize their allocation (ÁLVAREZ MALVIDO et al., 2021; FONDACARO et al., 2019; GELDMANN et al., 2018; MASULLO et al., 2020; PETIT et al., 2018).

The positive management effectiveness we found also indicates certain homogeneity among the parks regarding the influence of the evaluated indicators. This assumption is congruent with the clustering and independence analyses (Chi-square), which showed, respectively, that parks are distributed in similar groups and the final outcome of effectiveness (medium or satisfactory) is not significantly related (i.e., dependent) of the evaluated indicators. A study on protected areas in the southern region of Ecuador found similar results using correlation analyses, in which the authors found that management effectiveness, the extent of protected areas and the age of protected areas do not correlate significantly and are not determinants for the score on the effectiveness of management of protected areas (LÓPEZ-

RODRÍGUEZ; ROSADO, 2017).

Our study is congruent with the results obtained from the Protocol for Integration of Protected Areas of the Amazon Biome – IAPA, for the evaluation of the effectiveness of the management of the protected areas of the Amazon region in Peru (NAVARRETE, 2019). Results obtained by applying the form known as METT (The Management Effectiveness Tracking Tool) (STOLTON; DUDLEY, 2016), to 34 Protected Areas, found that National Parks (12 national parks) varied in management effectiveness from medium (8.3%) to high (91.7%) progress level. However, Navarrete (2019) also found that the factors that still need greater investment to increase success and effectiveness of management correspond to partnerships, territorial planning and demarcation, implementation and strengthening of programs aiming useful information for management, research, infrastructure and strategies to face climate change. Despite using a different evaluation methodology, Navarrete (2019) also found similar results concerning the 11 Peruvian National Parks that we evaluated. The findings of these studies corroborate the suitable application of Scenario Matrix methodology proposed in the present study to evaluate effectiveness management. Besides that, it should be noted that when protected areas are in an establishment, strengthening phase or under a specific threat, they might require annual assessments, but in general intervals of two to five years are generally adequate to reveal changes and guide management (HOCKINGS; LEVERINGTON; COOK, 2019).

Coelho Junior et al. (2020) mentions that effectiveness evaluation generates knowledge that support decision-making in protected areas, besides contributing to international discussions about benefits from forest conservation and carbon sequestration projects based on sustainable land use. The effective progress of management is pointed out as a way to likely reduce deforestation, conversion of natural areas to pastures and recurrent fires (DA SILVEIRA et al., 2012; HERINGER et al., 2020; KERE et al., 2017; NOGUEIRA et al., 2018; RESENDE et al., 2021). Therefore, control these actions is fundamental for the significant effectiveness of management in Peru, which also need to improve concerning monitoring, inspection power and strategic planning for fundraising (ESPIN; PERZ, 2021; MONTOYA-ZUMAETA; WUNDER; TACCONI, 2021) low performance indicators that were identified with the responses chosen by the managers of the scenario matrix questionnaires.

The evaluation results stand out from several other methodologies that have been proposed in order to assess the effectiveness of management in protected areas, without

involving considerable time or financial resources (LUNA-SÁNCHEZ; SKUTSCH, 2020; PRESTES; PERELLO; GRUBER, 2018). The scenario matrix methodology proved its flexibility of application and inexpensiveness, being able to generate data and results in a short time through broad indicators that consider different scenario characteristics in different geographic locations (LIMA; RIBEIRO; GONÇALVES, 2005). This can assist the evaluation of management plans by coordinators and managers among different protected areas and national parks. Finally, it is necessary to emphasize that the proposed methodology aims to strengthen and encourage investments in research to seek development and application of flexible, comprehensive and effective methods for generating information based on applicable assessments about management effectiveness in protected areas, thereby providing updated data and allowing for realistic validation of biodiversity conservation.

5. CONCLUSIONS

Our findings lead us to conclude that Peru's national parks are currently well managed, with average and satisfactory levels of effectiveness. This is a good indicative that the parks evaluated have been successful in maintaining management effectiveness in recent years. Such successful management is mainly related to the positive ranks obtained for the indicators of expropriation, relationship with Surroundings, protection and inspection programs and management plan. Nevertheless, we identified some indicators that need to be improved, especially for parks that showed medium management effectiveness. The scenario matrix methodology demonstrated its good functionality as a dynamic model of reality that, through its direct and impartial responses, can assist managers to maintain and more accurately allocate financial resources in protected areas through the identification of indicators with low performance.

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APPENDIX

Questionnaire with the scenario matrix methodology applied to managers.

National Park:

Manager: Formation:

I. LAND SITUATION.

A. Demarcation of the National Park:

- ❑ The National Park has its perimeter fully demarcated, which is fully known by its confronters/neighbors.
- ❑ The National Park is demarcated, but there is litigation with the confronting ones.
- ❑ The National Park has partial demarcation of its boundaries and there is no litigation with the confronting ones.
- ❑ The National Park has a reasonable demarcation and there is no satisfactory information for the confronters.
- ❑ The National Park has no demarcation of its boundaries.

B. Expropriation of Private Lands:

- ❑ The National Park is totally expropriated and/or with all owners indemnified.
- ❑ The National Park is expropriated, but some owners have not been indemnified.
- ❑ More than 50% of the National Park is expropriated and indemnified.
- ❑ The National Park has up to 50% of its area expropriated and indemnified.
- ❑ The National Park does not have any regularized hectares.

II. INFRASTRUCTURE AND PERSONNEL.

A. Human Resources:

- ❑ The National Park has a satisfactory number of employees (1 for every 500 ha), with high- and mid-level professionals, most of whom have already undergone some sort of training or capacity building in the last 10 years.
- ❑ The National Park has a satisfactory number of employees, professionals with higher and intermediate levels, but most have not undergone training or capacity building in the last 10 years.
- ❑ The National Park does not have a satisfactory number of employees, but some have already gone through training or capacity building in the last 10 years.
- ❑ The National Park does not have a satisfactory number of employees and they have not undergone training or capacity building in the last 10 years.
- ❑ The National Park has no employees.

B. Infrastructure:

- ❑ The National Park has sufficient equipment (vehicles, machines, tools) and suitable infrastructure (roads, buildings, firebreaks and fences).
- ❑ The National Park has suitable infrastructure, but it does not have enough equipment.
- ❑ The National Park has enough equipment and does not have suitable infrastructure.
- ❑ The National Park does not have enough equipment nor suitable infrastructure.
- ❑ The National Park does not have equipment nor infrastructure.

III.PARTNERSHIPS.

A. Relationship with the surroundings:

- ❑ The National Park has significantly contributed to the development of the surroundings and counts on their effective participation in the management of its the area.
- ❑ The National Park has contributed to the development of the surroundings, but it does not count on the participation of neighboring residents in the management of the area.
- ❑ The National Park relies on the participation of the surrounding residents in the management of the area, but this has not contributed to its development.
- ❑ The National Park does not count on the participation of the surrounding area in its management and contributes only indirectly to regional development.
- ❑ The National Park does not count on the participation and does not contribute to regional development.

B. Institutional Partnerships:

- ❑ The National Park has a co-management partnership (administration) with another institution.
- ❑ The National Park does not have a co-management partnership but has a permanent partnership (there is more than 05 years) with other institutions.
- ❑ The National Park has sporadic partnerships for specific programs.
- ❑ The National Park has not had partnership activities for over 05 years.
- ❑ The National Park has never had a partnership with other institutions.

C. Financial Resources:

- ❑ The National Park receives sufficient resources for its management, besides always counting on other external parties (NGOs, Project Financing Institutions, Private Initiative, etc).
- ❑ The National Park does not receive enough government resources, but it always has external support.
- ❑ The National Park has only government resources, but these do not allow for the adequate management of the area.
- ❑ The resources received are insufficient for the management and administration of the area.
- ❑ The National Park does not receive any resources for funding and capital of the area.

IV. PROTECTION AND MANAGEMENT

A. Protection and Inspection Programs

- ❑ The National Park has a protection plan in place.
- ❑ The National Park has a protection plan, but it is not being fulfilled.
- ❑ The prevention of damage to the National Park is only done through campaigns.
- ❑ The National Park do not come working on damage prevention, but has sought to exert control as far as possible, or vice versa.
- ❑ The National Park does not have damage prevention programs and, due to lack of infrastructure, it has not been adequately exercising control.

B. Fire Control:

- ❑ The National Park has been working intensively on prevention, has an equipped and trained brigade and has been reducing the historical average of burned area and/or number of outbreaks.
- ❑ The National Park has worked intensively on prevention, has an equipped and trained brigade, but it is not managing to reduce the historical average of burned area and number of outbreaks.
- ❑ The National Park has equipment, but the brigade has not undergone training in the last five years.
- ❑ The National Park has equipment, but it does not have a constituted brigade.
- ❑ The National Park does not have equipment and does not have a constituted brigade.

C. Management

- ❑ The National Park has an updated management plan which is being complied with.
- ❑ The National Park is preparing or updating the management plan.
- ❑ The National Park has only an emergency action plan in compliance.
- ❑ The National Park has a management plan with more than 10 years of elaboration.
- ❑ The National Park has no management plan or emergency action plan.

D. Scientific Research

- ❑ The National Park has a permanent research program with adequate monitoring, which significantly contributes to the management of the area.
- ❑ The National Park has been adequately monitoring the research , but their results have not contributed to the management of the area.
- ❑ The National Park accompany the conduct of research, but the results of these generally do not return to the area management.
- ❑ The National Park has not been able to exercise adequate control over the research undertaken.
- ❑ There has been no research being carried out in the National Park for more than 05 years.