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Analysis of the Ecosystem Management of the Yanachaga-Chemillén National Park

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Abstract

The article analyzes the ecosystem management of Yanachaga-Chemillén National Park, the core of the Oxapampa-Asháninka-Yánesha Biosphere Reserve, as a representative model of integrated management of protected natural areas in the central jungle of Peru. Through qualitative research based on a systematic review of SERNANP Master Plans, environmental regulations and specialized scientific literature, the main components of management are evaluated: participatory governance, ecological zoning, management programs, ecosystem restoration and economic valuation of ecosystem services, with an emphasis on water regulation. The results show that inter-institutional coordination between the state, non-governmental organizations and local communities has strengthened biodiversity conservation and the ecological functionality of the park. Likewise, the implementation of Mechanisms for Compensation for Ecosystem Services (MERESE) is consolidated as a key tool for the financial sustainability and social legitimacy of conservation, by directly linking water resource users with the protection of the ecosystem that provides it.

Keywords: Yanachaga-Chemillén National Park, ecosystem services, conservation, ecosystem management.

Introduction

Ecosystem management has established itself as a fundamental approach to the sustainable management of natural resources, recognizing the complex interaction between ecological, social and economic components within natural systems. This paradigm emphasizes the conservation of ecological processes, ecosystem resilience and the integration of local actors in decision-making. Specifically, in megadiverse countries such as Peru, where marked altitudinal and climatic gradients converge, protected natural areas play a strategic role in conserving biodiversity and providing ecosystem services essential for human well-being (SERNANP, 2015). However, these areas face increasing pressures from agricultural expansion, landscape fragmentation and climate change, which require integrated management models based on scientific evidence.

Yanachaga-Chemillén National Park (PNYCH, according to its Spanish acronym) was established on August 29, 1986 by Supreme Decree No. 068-86-AG. It protects an area of 122,000 hectares in the province of Oxapampa, department of Pasco **(Figure 1)**. Its importance lies not only in its high biodiversity, characterized by altitudinal gradients ranging from 460 to 3,643 meters above sea level but also in its role as a regional water and climate regulator (Government of Peru, 2019).

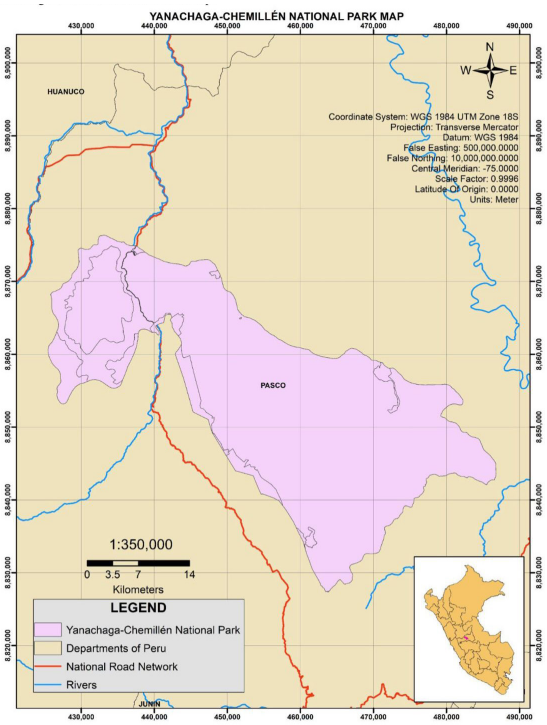

Figure 1: Yanachaga-Chemillén National Park map.

The protected area is located on the eastern slope of the central Andes in Peru, with an altitude gradient between 460 and 3,640 meters above sea level, generating high climatic heterogeneity with average annual temperatures ranging from 6°C to 24°C °C and rainfall exceeding 2,000 mm per year (SERNANP, 2015). These conditions allow for the development of montane forest, cloud forest and high Andean grassland ecosystems, which are home to emblematic species such as the Andean bear (Tremarctos ornatus), yellow-tailed woolly monkey (Oreonax flavicauda), macroinvertebrate and a high diversity of endemic birds and flora (SERNANP, 2015).

From a functional point of view, the park is the headwaters of important river basins (Huancabamba, Paucartambo and Palcazú) that feed into the Pachitea River system and the Amazon basin, playing a key role in regional water regulation (SERNANP, 2015). The ecological quality of these aquatic systems is reflected in the presence of benthic macroinvertebrates of the orders Ephemeroptera, Plecoptera and Trichoptera, widely used as environmental bioindicators.

Taxon	Master Plan 2005-2009	Other studies in the area
Plants	1 956	-
Mammals	49	90
Birds	527	248
Reptiles	19	19
Amphibians	34	48
Fish	135	-

Table 1: Accounting for biological diversity (species) in Yanachaga-Chemillén National Park.

Note: Extracted from Lavado-Solis et al. (2021).

In addition, Yanachaga-Chemillén National Park, also known as the "Pleistocene Refuge," has been recognized for hosting a wide variety of forest relicts, as well as for its record of abundant biodiversity **(Table 1)**, which includes new species such as amphibians, including Phrynopus manuelriosi and Phrynopus melanoinguini, and endemic flora, such as Columnea cesarii, Columnea yanachagaensis, Drymonia quinquagesima, and Drymonia vasquezii. The latter have been categorized as "Critically Endangered (CR)" due to the reduction and fragmentation of montane forests, mainly associated with the expansion of the agricultural frontier and burning in surrounding areas; in this context, their conservation is a priority (Government of Peru, 2019; Angulo, 2025; Government of Peru, 2025).

The management of high mountain tropical ecosystems and high forests poses significant technical challenges due to the complexity of biological interactions and anthropogenic pressure in buffer zones. In this context, the present study aims to analyze the ecosystem management of Yanachaga-Chemillén National Park and its contribution to the conservation of ecological processes and territorial sustainability.

Unlike theoretical approaches focused on the capacity to return to the initial state after disturbances, this analysis focuses on active and preventive management. The park's administration has evolved from a strict protection model to an integrative management model that involves civil society and international cooperation. The effective management of this Protected Natural Area (PNA) depends on the operability of its planning instruments, specifically the Master Plan and the capacity to execute its resource management, restoration and control programs.

However, the management of the National Park faces multiple pressures, such as the expansion of migratory agriculture, illegal logging, poaching and pressure from human settlements on the perimeter. These factors not only impact biodiversity but also the hydrological processes that feed priority watersheds for rural and urban populations.

The objective of this study is to evaluate the management structure of

Yanachaga-Chemillén National Park, identifying the roles of the institutions involved, the effectiveness of current management plans and the application of economic valuation tools that justify investment in the conservation of the area. It seeks to answer how the interaction between technical zoning and socio-environmental agreements with NGOs and local communities shapes the current state of conservation of the park.

Materials and methods

This research is qualitative, based on a systematic review of official secondary sources and indexed scientific literature. As Guzmán (2021) argues, the qualitative method allows us to understand the context of today's world in order to identify various situations that should be investigated from a more comprehensive perspective. In this research, the management implemented will be analyzed in order to examine the evolution of environmental management instruments. For this reason, the Yanachaga-Chemillén National Park Master Plans, SERNANP management reports, technical documents from the Ministry of the Environment (MINAM), among others, were analyzed, prioritizing the analysis of the park's ecosystem management.

In this regard, data was analyzed focusing on the categorization of strategies into three areas: governance and actors (Management Committee), zoning, direct management and economic valuation (hydrological services).

Results and discussion

1.1. Regulatory and conceptual framework for ecosystem management in Peru

The management of Protected Natural Areas (PNAs) in Peru is governed by a hierarchical legal framework that has its constitutional basis in Article 68 of the Political Constitution and is mainly implemented through the Protected Natural Areas Law (Law No. 26834) and its Regulations (Supreme Decree No. 038-2001-AG).

According to current regulations, environmental management is not limited to passive protection but requires an active management approach aimed at conserving ecological and evolutionary processes, ensuring the continuity of ecosystem services for the benefit of society. Within this regulatory framework, ecosystem services are recognized as water regulation; maintenance of biodiversity; carbon sequestration and storage; landscape beauty; soil erosion control; provision of genetic resources; air and climate quality regulation; pollination; natural risk regulation; recreation and ecotourism; nutrient cycling and soil formation (Supreme Decree No. 009-2016-MINAM, Art. 6, 2016).

The National Service of Natural Areas Protected by the State (SERNANP), as the governing body, establishes that management must be based on the Ecosystem Approach. This approach, adopted in the Master Plan for Protected Natural Areas, is defined as a strategy for the integrated management of land, water bodies and living resources alike, promoting their conservation and sustainable use in an equitable manner. Unlike previous models of isolated preservation, Peruvian regulations require that protected natural areas be managed as an integral part of

a larger landscape, coordinating in situ conservation with surrounding territorial development (Law on Protected Natural Areas, Art. 2, 2017). Instrumentally, ecosystem management is implemented through mandatory planning documents:

- **Master Plan:** This is the highest-level planning document for a protected natural area. It must be developed through participatory processes and is valid for five years. This instrument defines zoning, a technical tool that organizes space according to ecological fragility and potential use, establishing areas of strict protection, wilderness, tourist use, among others (Law on Protected Natural Areas, Art. 20, 2017).
- **Participation and governance:** The regulation stipulates that administration of the area is not the exclusive responsibility of the State but must involve local actors, regional governments and the private sector in non-binding but strategic decision-making for the area's operation (Supreme Decree No. DS 038/2001-AG, Chapter III, 2001).
- **Valuation and compensation:** The enactment of the Law on Compensation

Mechanisms for Ecosystem Services (Law No. 30215) and its regulations, the Peruvian legal framework formally incorporates the economic valuation of natural heritage. This empowers ANP managers to establish voluntary agreements for conservation, recovery and sustainable use actions, financed by contributors (service users), which is key to the financial sustainability of national parks such as Yanachaga-Chemillén.

1.2. Governance structure and the role of the management committee

The administration of Yanachaga-Chemillén National Park falls under the responsibility of the Park Headquarters, which is attached to SERNANP. However, ecosystem management in the territory operates under a participatory governance model. The main coordinating mechanism is the Management Committee, which is made up of representatives from native communities (Yánesha), Austro-German and Andean settler communities, local governments and private organizations. In other words, management is not unilateral.

Strategic alliances with non-governmental organizations (NGOs) have been crucial in filling budgetary and technical gaps in the state. Key actors have been identified:

- *Desarrollo Rural Sustentable (DRIS)*: It has played a fundamental role in the buffer zone, promoting agroforestry systems that reduce agricultural pressure on the core area. Its intervention focuses on reconciling sustainable economic activities with the park's objectives.
- *Instituto del Bien Común (IBC):* Focused on landscape management and land use planning in the Pachitea basin and the BIOAY Biosphere Reserve, providing cartographic and legal inputs for the defense of the territory.
- *Jardín Botánico de Missouri*: Although its role is primarily scientific, the floristic information generated is the basis for the ecological zoning of the Master Plan, allowing for the identification of areas of high biological sensitivity that require strict protection.

Therefore, the 2019-2022 Master Plan for Yanachaga-Chemillén National Park incorporated a governance approach geared toward the integrated management of the protected natural areas (PNAs) that make up the Yanachaga Complex and the Oxapampa Asháninka Yánesha Biosphere Reserve, through strategic coordination between the national park headquarters, the Yanesha Communal Reserve, and the San Matías-San Carlos Protected Forest (Presidential Resolution No. 011-2022-SERNANP, p. 20, 2022).

This governance structure is based on inter-institutional coordination and the participation of the Management Committee, a consultative and participatory body that brings together local actors, communities and public and private organizations and plays a key role in coordinating actions, monitoring management and ensuring the social legitimacy of decisions. The implementation of this scheme seeks to position PNAs as strategic assets of the territory, strengthen the social value of their joint role as providers of ecosystem services that generate well-being and consolidate the landscape approach as the backbone of territorial planning and management.

1.3. Zoning and ecosystem management plans

The current Master Plan establishes zoning regulations for land use, dividing the park into: Strict Protection Zone (SPZ), Wilderness Zone (WZ) and Tourism and Recreation Zone (TRZ), among others.

Ecosystem management is implemented through the following management programs:

- Park ranger and surveillance program: Monitoring is carried out through strategic surveillance posts. The strategy has shifted from purely punitive control to preventive control through satellite early warning systems (Geobosques - MINAM) to detect deforestation in near real time.
- Public use plan: Specific areas such as the San Alberto sector have been zoned for ecotourism. Management here focuses on minimizing the impact of visitors on the soil and wildlife through low-impact infrastructure (elevated trails, interpretive signage).
- Buffer zone management: This is the critical point of management; anthropogenic activities in the area, such as agriculture and livestock farming in the buffer zone, pose a threat to the biodiversity of the national park. Current management plans do not intervene directly within the park (where extraction is prohibited) but rather manage the surrounding ecosystem to ensure biological connectivity.

1.4. Ecosystem restoration and recovery plans

The strategies outlined in the 2019-2022 Master Plan for Yanachaga-Chemillén National Park form a comprehensive management approach aimed at achieving environmental objectives, providing ecosystem services and promoting human well-being. Eleven strategies were created that not only directly address the main threats identified (such as deforestation, hunting, forest fires and poor agricultural practices) but also capitalize on opportunities related to the sustainable use of ecosystem services (Presidential Resolution No. 011-2022-SERNANP, 2022). Particularly noteworthy are the actions aimed at strengthening surveillance and control, environmental education with an intercultural and gender focus, the physical sanitation of the protected area's boundaries and the monitoring of key species such as the spectacled bear (Tremarctos ornatus) and the cock-of-the-rock (Rupicola peruvianus), which are strategic elements for biodiversity conservation and evidence-based decision-making (Presidential Resolution No. 011-2022-SERNANP., 2022).

The Master Plan also emphasizes the consolidation of governance and participatory management as central pillars for the sustainability of the Yanachaga-Chemillén National Park, promoting inter-institutional coordination between the protected natural areas of the Yanachaga Complex and the Oxapampa Asháninka Yánesha Biosphere Reserve. Strategies such as strengthening the Management Committee,

regulating vehicular traffic in the Huancabamba Canyon, diversifying nature tourism and developing capacities in good agricultural practices compatible with conservation reflect a clear landscape approach, where conservation is integrated with local development (Presidential Resolution No. 011-2022-SERNANP, 2022). Finally, the promotion of scientific and applied research positions the National Park as a "living laboratory," aimed at generating knowledge about ecosystems, biodiversity, ecosystem services and well-being, contributing to adaptive management and the formulation of more effective conservation policies in highly biodiverse contexts such as Peru (Presidential Resolution No. 011-2022-SERNANP., 2022).

1.5. Economic valuation of ecosystems and compensation mechanisms

One of the most significant advances in the modern management of the park is the transition from an intrinsic valuation (biodiversity per se) to an instrumental valuation of its ecosystem services, specifically water resources. The Yanachaga-Chemillén National Park supplies water to the city of Oxapampa and surrounding areas through the San Alberto River basin and other micro-basins.

On the other hand, using economic valuation methodology, they have quantified the contribution of the cloud forest to horizontal fog capture and flow regulation. This has enabled the implementation of water-related Payment for Ecosystem Services Mechanisms (MERESE). Under this scheme, the Central Selva Sanitation Services

Company (EPS) collects a percentage of the water tariff from users in Oxapampa. These funds are allocated to a trust used exclusively to finance conservation, monitoring and restoration projects in the upper part of the basin (within and around in the Nacional Park). This model closes the management cycle: the beneficiary pays and the fund ensures the integrity of the provider ecosystem (IIAP, n.d.).

However, in order to assess the economic value of the national park, the CERA protocol can be used to verify the current situation. The study by Trama et al. (2020) integrates the Andean Biotic Index (IBA), the River Habitat Index (IHF) and the Andean Stream Index (Qbr-And), whose combination allows the calculation of the Ecological Status Index of Andean Rivers (ECOSTRIAND) for each sampling station. In addition, the FBI and BMWP-Col indices were determined in order to compare water quality. The study's sampling campaigns were carried out in seven river basins, covering an altitudinal gradient between 1,800 and 2,500 meters above sea level, both in the upper zone located within the Yanachaga-Chemillén National Park and in the middle and lower sections, located in its buffer zone (Trama et al., 2020).

In total, 179 taxa were recorded, corresponding to 66 families and 14 orders. The IHF and Qbr-And values within the national park showed optimal conditions, with a general trend toward a decrease in ecological quality as the distance from the protected area increased (Trama et al., 2020). The IBA showed very good ratings in all basins and points evaluated; however, the integration of the three indices revealed a reduction in ecological status (ECOSTRIAND) from Very Good to Good and Fair categories. Overall, the results indicate that the ecological status of rivers progressively deteriorates as they move away from the protected area, which is associated with a greater degree of disturbance to riparian forests. Finally, the legal protection framework for these riparian ecosystems in different countries of the Americas is analyzed, with an emphasis on the Peruvian context (Trama et al., 2020).

Within this framework, a study estimated the willingness to pay (WTP) for biodiversity conservation in Yanachaga-Chemillén National Park (YCNP) using the contingent valuation method, considering hypothetical conservation scenarios for 6, 9 and 12 key species that ensured 50% of ecosystem functionality. The results showed that WTP was mainly associated with the functional role of these species in ecosystem resilience, with a marginal WTP of S/ 23.59 for their conservation, regardless of the number of species considered (Lavado-Solisa et al., 2021).

Similarly, in the study by Mogollón et al. (2023), 2,414 surveys were conducted during the first quarter of 2020 to measure the willingness to pay (WTP) for the conservation of biodiversity in the National Park, which is approximately $6 USD per household. which is relevant not only because it provides information on how the local population values this protected area but also because it has direct implications for the formulation and implementation of environmental conservation policies in the region.

Conclusion

The ecosystem management of Yanachaga-Chemillén National Park demonstrates the consolidation of a technical governance model that integrates the administrative operations of SERNANP with the logistical execution of strategic allies such as the Instituto del Bien Común and DRIS. The rigorous application of the zoning established in the Master Plans, coordinated with ecological restoration strategies through assisted natural regeneration in the Buffer Zone, has ensured structural connectivity between the core area and the surrounding productive landscapes. This active management approach has been instrumental in mitigating the fragmentation of critical habitats and containing the advance of the agricultural frontier, validating the effectiveness of conservation agreements signed with local communities and settlements for land use planning.

Likewise, the implementation of water-based Payment for Ecosystem Services Mechanisms (MERESE) is a decisive component for the financial sustainability of the area, transforming the economic value of water regulation in the San Alberto River basin into tangible investment flows for monitoring and control activities. This scheme instrumentalizes conservation by contractually linking EPS Selva Central users to the maintenance of natural infrastructure, demonstrating that the long-term viability of the PNYCH depends on ensuring its functionality as a provider of ecosystem services, thus legitimizing protection policies under criteria of cost-effectiveness and direct socioeconomic benefit.

Finally, rigorous zoning enforcement, complemented by ecological restoration and buffer zone management strategies, has contributed significantly to reducing habitat fragmentation and preserving critical ecological processes, especially those linked to regional water regulation. In this context, Payment for Ecosystem Services mechanisms emerge as the structural backbone that guarantees the long-term sustainability of the protected area, by translating the functional value of ecosystems into financial flows for conservation.

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