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ANALYSIS OF THE SOCIOECOLOGICAL SYSTEM OF YASUNI NATIONAL PARK: ON THE WAY TO ADAPTATIVE MANAGEMENT PLANNING

SUMMARY

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Contents

LIST OF ABBREVIATIONS

CBD - Convention on Biological Diversity

CPA - Community Protected Area

ES – Ecosystem Services

MAATE - Ministry of Environment, Water and Ecological Transition

MARISCO – Management of Vulnerability and Risk at Conservation Sites

ME - Ministry of Environment

METT - Management Effectiveness Tracking Tool

NGO - Non-Governmental Organization

NP – National Park

NSPA - National System of Protected Areas

PA – Protected area

SES - Socioecological System

SOHNAS - State Owned Heritage Natural Areas Subsystem

VMP - Visitor Management Plan

YBR - Yasuní Biosphere Reserve

YNP - Yasuní National Park

ABSTRACT

The management of PAs seeks to guarantee the protection, conservation, functionality, and sustainability of ecosystems. This management must be integrated and participatory, based on conservation objectives, and at the same time must be compatible with biodiversity, conservation values, socio-ecology, ES, and sustainable development. In the Amazon, PAs represent approximately 45% of the territory, and in Ecuador, PAs cover about 20.56% of the national territory. YNP is the largest PA in continental Ecuador and one of the most biologically and culturally diverse. The objective of this research was to analyze the SES of YNP, on the way to adaptive management planning (the study was approached from the perspective of the SES, understanding PAs as dynamic systems, in constant interaction, with transforming economic, ecological, social and evolutionary changes; which promote systematic learning from mistakes, to build more efficient and resilient systems). In the first phase of this study, METT, an international methodology based on a questionnaire that includes six elements of the management cycle: context, planning, inputs, processes, outputs, and outcomes, was applied. This questionnaire was applied through interviews with the YNP management team. For the following phases, the MARISCO methodology was applied, based on bibliographic analysis, interviews, semi-structured interviews, and focus groups with members of four Kichwa communities, one local guide, two community leaders, and the park's management team. The results indicate that the park's management effectiveness indexes range from 54.2% (Inputs) to 83.3% (Context), with an overall average of 64.6%, which is considered a good management. The weakest points in terms of management are related to budget allocation, tourism agreements, and relations with communities and indigenous peoples. In addition, according to the perception of the communities and members of the park administration, the main problems are derived from oil exploitation, the agricultural sector, and deforestation. The main forest ecosystem benefits identified were food, health, and cultural identity. Also, according to respondents and focus group participants, oil extraction, infrastructure, and small-scale agriculture were considered the main direct drivers of forest ecosystem change. The indirect drivers of change identified by responders were land governance and promotion of extractive activities, poverty and lack of income sources, and presence of colonists in the Park area. The study concludes that for better management, it is necessary to include communities in decision making and budget execution. In the same way, other stakeholders should be involved in the search for management solutions, considering adaptive management from a socio-ecological point of view.

INTRODUCTION

Ecosystems worldwide have undergone significant change over the last 50 years of human history (Portalanza et al., 2019) and scientific evidence over the last 20 years has exposed the direct relationship and dependence of human well-being on the maintenance of natural systems (Schick et al., 2019). The ecosystem changes are primarily associated with food production, freshwater needs, and the effects of fossil fuel use (Portalanza et al., 2019). In turn, the impacts are evident in all ecosystems, modifying global biogeochemistry, driving climate variation, and leading to the loss of biological biodiversity (Tapia-Armijos et al., 2017). In this context, although PAs establishment and management constitute the backbone of biodiversity conservation (Leverington et al., 2010), the levels of complexity of environmental problems have prompted the search for solutions focused on the adaptive management of PAs (Schick et al., 2019), that must include a better understanding of non-linear relationships affecting SESs in which PAs are anchored.

Among numerous methods, adaptive MARISCO (Ibisch and Hobson, 2015) allows ecosystem analysis and adaptive planning to be based on ecosystem theory, science, and risk management (Ibisch and Hobson, 2015). It is established on sustainability at its core and starts from a practical analysis of the causes and dynamics of ecosystem evolution, linking development, poverty, and social systems (Ibisch and Hobson, 2015).

Ecuador is considered one of the 17 mega diverse countries in the world, having an impressive wealth of biological and cultural diversity (Negru et al., 2020). It has the highest relative biodiversity (Negru et al., 2020), and the highest concentration of biodiversity per square kilometer due to climatic, geological, evolutionary, biogeographical, geographical, and ecological factors, such as the presence of the Andes Mountains, the Equatorial Line and the influence of ocean currents, and the Amazon basin (Celi and Villamarín, 2020), which facilitates the formation of different climatic floors and ecological landscapes with very diverse ecosystems (MAE, 2018; Vanacker et al., 2018). Ecuador hosts 7.3% of vertebrate species and 7.6% of vascular plant species described worldwide (Dornhoff et al., 2019), while the tropical Andes, in terms of vertebrate species, endemic vertebrates, and endemic plants lead the list globally (Seed, 2019). 79% of the existing plant formations in Ecuadorian territory are found in the NSPA. While Ecuadorian PAs are home to 26 indigenous nationalities (MAE, 2018).

The Ecuadorian state recognizes biodiversity as a competitive advantage and establishes as a priority area within national planning those sectors that depend directly on nature and its biological resources (MAE, 2018). Ecuador, through the NSPA, seeks to safeguard this biodiversity and has implemented a national payment or reward system for preservation and governance both within PAs and their buffer zones (Cuenca et al., 2018; De Koning et al., 2011). To prevent illegal trade, Ecuador is a member of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Nagoya Protocol, and the CBD. Among the services provided by this biodiversity are carbon sequestration and nutrient cycling, and it contributes to food and medicine production (Kleemann et al., 2022). Biodiversity also plays a crucial role in maintaining the overall health and resilience of ecosystems, making it essential for the long-term survival of species and ecosystems.

Despite the various strategies and initiatives implemented by the Ecuadorian government at the national level to develop sustainable natural resource management, the results are still emergent (Mestanza-Ramón et al., 2020; Negru et al., 2020). Over the last few years, a clear need for replacing traditional approaches with system-based approaches, including spatial analysis, ecosystem diagnostic analysis, increased understanding of stresses, scenario planning, and vulnerability in adaptive conservation management (Ibisch and Hobson, 2015), thus creating opportunity for using MARISCO methodology.

YNP is a very important part of Ecuadorian NSPA, being the largest PA in continental Ecuador. Considering the very complex SES in YNP rising significant challenges as people-park and human-wildlife conflicts (Bliemsrieder et al., 2011; MAE, 2021a), an adapted management approach was adopted in analyzing the dynamics and relationships between the ecological and socio-economic systems. In this context, the MARISCO methodology was considered the most appropriate.

The core objectives of an evaluation of natural resources and their services are: (i) to shape and implement sustainable land-use systems through the measure of profits that could be derived from the conservation, protection, and/or restoration of ecosystems, (ii) to implement policies relating to territorial organization, conservation, and sustainability, or even (iii) to establish payments for environmental services. Based on the above arguments, this work aimed to evaluate the capacity of the Ecuadorian Amazonian rainforest to provide ES, through evaluating the plant uses, capacity to provide products and services, as well as the perception of the existing landscape management systems in the view of local stakeholders. The obtained information is important in complementing the existing (limited) databases and statistics on the natural capital and ES, and it gives a point of reference for the establishment of policies and local programs to favor the conservation of forests. The core components of this research were the following: (i) identification of ES, (ii) analysis of local population perception of the flow of ES, and (iii) evaluation of the commitment of locals support conservation measures.

CHAPTER 1. BACKGROUND OF ECUADOR'S NSPA, STRATEGIES AND INSTITUTIONAL LEGAL FRAMEWORK

1.1. PAs system in Ecuador

1.1.1. History and main PAs

Ecuador, a megadiverse country, harbors 91 ecosystems and significant percentages of global bird, orchid, amphibian, and mammal species (MAE, 2015). Indigenous communities play a critical role in conservation, integrating traditional knowledge with modern practices (Taylor et al., 2022). Since 2008, the Sumak Kawsay principle has embedded sustainable development in the constitution, emphasizing biodiversity through cultural and legal mechanisms (Antolín-López et al., 2022; Rampheri et al., 2022). Conservation in Ecuador began in 1893, initially focusing on fishing regulations and Galapagos turtle protection (MAE, 2010). Legal milestones in the 1930s established Galapagos as a protected area, followed by the Pululahua Geo-botanical Reserve (Muñoz, 2017). Despite early challenges, the 1970s saw a strategic conservation shift (Putney, 1976), culminating in the 1981 Forest and Natural Areas and Wildlife Conservation Law, laying the foundation for the country's extensive PAs network (MAE, 2007; Vásquez and Ulloa, 1996).

Ecuador ranks second in Latin America (IUCN, 2022), after Colombia (Paz Cardona, 2020), for the extent of territories dedicated to ecosystem protection, covering 20.56% of its land and 19.15% of territorial waters with 73 PAs (MAE, 2021b). Ecuador's National System of Protected Areas (NSPA) encompasses diverse ecosystems (MAE, 2007; MAE, 2016a). Covering from sea level to 6,700 meters (MAE, 2015). Managed by the state (Asamblea Nacional, 2008), the NSPA safeguards vast biodiversity, highlighting its comprehensive approach to environmental conservation (MAE, 2016b).

In Ecuador, NPs cover areas over 10,000 hectares with minimal human alteration (MAE, 2016b). Ecuador has 15 NPs (Figure 1).

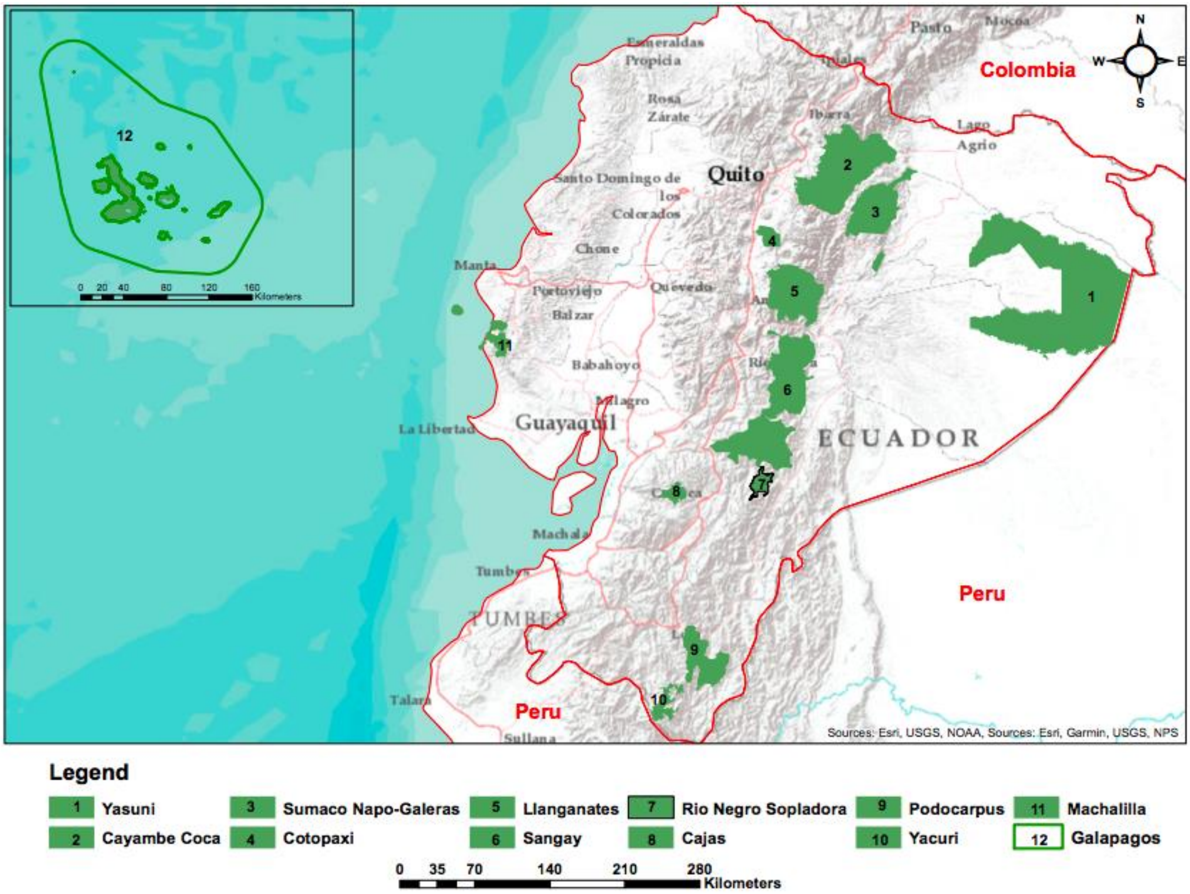

Figure 1. Ecuador NPs location (Negru et al., 2020)

1.1.2. Regulatory and Institutional framework for PAs management in Ecuador

Ecuador's legal system prioritizes the Constitution and includes specific environmental laws since 1971 (Asamblea National, 2008). This hierarchical legal framework encompasses international treaties down to local ordinances (Zárate, 2013).

In 1993, Ecuador ratified the Convention on Biological Diversity (CBD), emphasizing its dedication to biodiversity (Albán, 2001). The Ministry of Environment was established in 1996 as the environmental authority (MAE, 2007). The 1998 Constitution institutionalized the NSPA, aligning with international environmental standards and treaties to conserve biodiversity (Manosalvas et al., 2012).

Ecuador has implemented several policies for biodiversity conservation, from 1999 to 2030 (Albán, 2001). The 2008 Constitution emphasizes environmental sustainability, recognizing nature's rights and cultural diversity (MAE, 2018). Ecuador's Ministry of Environment, now called MAATE since June 2021, oversees PAs, focusing on sustainable practices (Table 1).

Besides, MAATE is the Ecuadorian state entity responsible for the administration of NSPA, having decentralized branches in 10 regions and local administration for each PA (Nguyen et al., 2012).

Table 1. MAATE attributions and responsibilities (MAATE, 2021)

Department	Attributions and responsibilities

ME and Water	Responsibilities cover policy establishment for water and protected areas.
Vice ME	To involve guiding environmental strategy, and overseeing environmental regulations.
Undersecretary of Environmental Quality	To approve and oversee initiatives aimed at pollution prevention and control.
Director of Environmental Regularization	To develop or update technical norms for environmental regulation.
Director of Environmental Regulation and Control	To elaborate national environmental policies related to environmental quality.
Undersecretary for Natural Heritage	To promote and ensure the conservation, recovery, and sustainable use of biodiversity ecosystems.
Director of PAs and other forms of conservation	To coordinate, manage, and evaluate the NSPA.
Director of Forestry	To develop policies, strategies, and technical norms for managing and governing the Natural Forests of the National Forest Heritage.
Biodiversity Director	To create tools and establish wildlife health standards, identify conservation priorities, and plan related research and projects.
Director of Environmental Education and Water	To manage and operate groups for the National Environmental Education Strategy.

1.1.3. Ecuadorian institutional framework for PAs regulation, planning and managing

In Ecuador, while the Ministry of Environment (ME) leads PA management (Figure 3), various public and private institutions also contribute, facilitating a collaborative management approach (Montes de Oca et al., 2018; Table 2).

Table 2. Management model legally recognized in the legislation of Ecuador (Montes de Oca et al., 2018; Negru et al., 2020)

Management model	Objective	Members	Weaknesses
Management Committee	Consulting bodies, that do not make decisions, but contribute to the management of the PA.	Local, provincial, parish, community, public, private, academic, and social organizations legally constituted	Internal organization, technical, operational, and self-management

Meanwhile, PAs generally operate as shown in Table 3.

Table 3. Management and administration of YNP (Negru et al., 2020; Zárate, 2013)

Areas	Responsibilities	Activities
Directorate of PAs, the Directorate of Forests, the Under Secretary of Biodiversity, and other units belonging to the ME.	Retains the responsibility and enforcing regulation of the conservation of biodiversity in PAs	Applies each of the legal and environmental regulations within Pas.
PA manager, rangers, and the technical teams.	Execute the approved management plan daily.	Management programs include conservation and management of natural and cultural heritage.

1.1.4. PA management effectiveness

Ecuador pioneered in implementing national tools for evaluating PAs management, starting in 1999 with the Ecuador MEE (Valarezo et al., 1999). This tool aimed to assess the management of Ecuador's NSPA based on earlier conservation strategies (Hockings et al., 2006; Valarezo et al., 1999). Despite its initial application in 24 PAs, further development and follow-up were recommended but not continued, although the Galapagos NP Service developed and used a local evaluation methodology between 1996 and 2004 (Table 4; Valarezo et al., 1999).

Table 4. Management effectiveness assessments for NPs in Ecuador (Ganzenmüller et al., 2010; GDPAME, 2020; MAE, 2007; MAE, 2020; Negru et al., 2020)

NP	Assessment methodology	Year
Galapagos	Galapagos NP Service method	1996 – 2004
	World Heritage Outlook Report	2012
Cotopaxi	Ecuador management effectiveness evaluation	1999
El Cajas	Ecuador management effectiveness evaluation	1999
Yasuní	Ecuador management effectiveness evaluation	1999
Sangay	Ecuador management effectiveness evaluation	1999
	World Heritage Outlook Report	2014
Machalilla	METT	2009
	Rapid assessment and prioritization of PA management	2007
Podocarpus	Rapid assessment and prioritization of PA management	2017
Sumaco Napo – Galeras	Ecuador management effectiveness evaluation	1999
Llanganates	Ecuador management effectiveness evaluation	1999
Yacuri	Rapid assessment and prioritization of PA management	2017
Cayambe – Coca	METT	2005, 2009

The Global Database on PA management reveals 62 assessments, with 10 using METT, including three in National Parks (Table 4; Ganzenmüller et al., 2010).

1.1.5. Scientific research relative to NSPA in Ecuador

Climate change affects species like *Tapirus pinchaque,* which are classified as Endangered (Sierra et al., 2002). Research highlights a reduction in suitable habitats, especially outside protected areas (Ortega-Andrade et al., 2015).
Cuesta et al. (2017) highlighted crucial biodiversity areas outside state Pas. The study showed the Amazon is highly climate-vulnerable (Cuesta et al., 2017). It stressed enhancing YNP's conservation efforts and called for stronger collaboration with local communities to improve management and conservation strategies (Ganzenmüller et al., 2010).
Ecuador's protective forests and forest heritage play a key role in biodiversity conservation. However, management effectiveness is often hampered by inadequate systems (Ganzenmüller et al., 2010). This approach aims to bridge conservation gaps and ensure the forests' long-term integrity by connecting them with the NSPA (Ganzenmüller et al., 2010). In Ecuador, private reserves operate independently, showing effectiveness comparable to state Protected Areas (López-Rodríguez and Rosado, 2017).

Stakeholder engagement in Latin American environmental projects varies: it can cause conflicts or enhance organizational performance through effective collaboration (Benites-Lazaro and Mello-Théry, 2019). Analysis in many countries revealed different levels of stakeholder integration and benefits, indicating that alignment with legal frameworks and stakeholder interests is crucial to avoid conflicts and ensure mutual benefits (Morán et al., 2016).

Dietz and Adger (2002) studied the relationship between the growing economy, biodiversity loss, and conservation efforts. This relation, in the majority of cases, is considered negative. However, is important to know that biodiversity loss is complex and includes factors, conditions, and many interactions (Dietz and Adger, 2002).

A study in the YNP buffer zone found indigenous and settler communities primarily reliant on forestry and income from oil activities and external aids (Loaiza et al., 2015). It revealed a strong dependence on unskilled labor in the oil sector (Loaiza et al., 2015). Additionally, the research highlighted the significant role of Amazonian Indigenous Territories and Pas in storing carbon (Marcinek and Hunt, 2019). It emphasized the importance of sustainable land use and development policies to protect these vital carbon stores (Marcinek and Hunt, 2019).

CHAPTER 2. THE STUDY AREA

2.1. General information on management

2.1.1. Establishment

The YNP was established in 1979 and later designated as a UNESCO Biosphere Reserve in 1989 for its biological and cultural significance (Bliemsrieder et al., 2011). Additionally, in 1999, the Intangible Conservation Zone was created to protect uncontacted Waorani groups (Bliemsrieder et al., 2011).

2.1.2. Management Objectives

The scope of the YNP is to maintain the ecological and cultural integrity of the YNP by promoting the participation of the actors involved in the protection and sustainable use of natural resources (Bliemsrieder et al., 2011).

2.1.3. Location

YNP is located at the Andes-Amazon intersection (Bass et al., 2010). It's in a high-rainfall area with no severe dry season, spanning across the Napo and Curaray Rivers in Ecuador's Napo and Pastaza Provinces (Figure 4; Bliemsrieder et al., 2011).

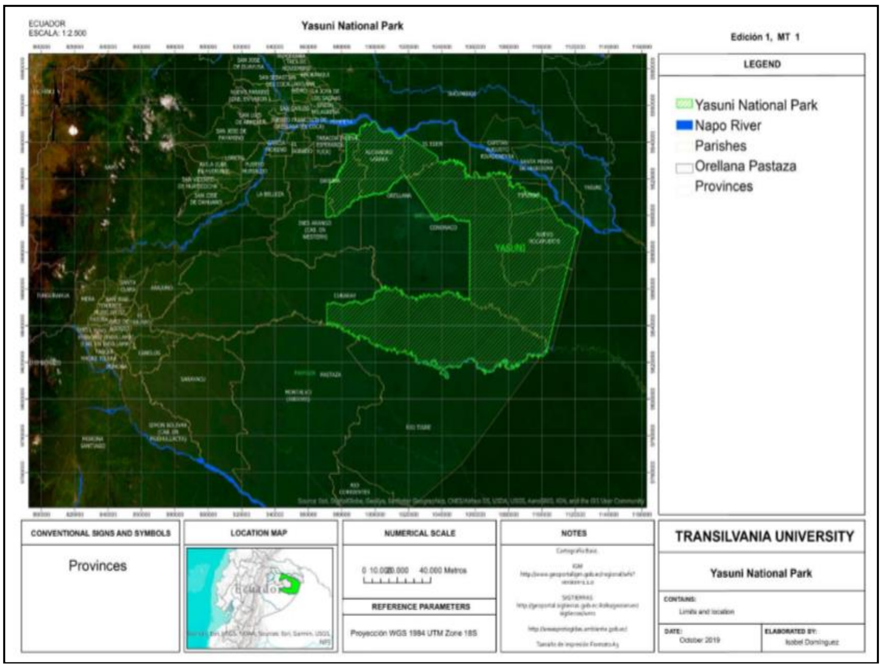

Figure 2. Map of YNP

2.1.4. Internal zoning system

Despite its designation as YBR, YNP lacks a comprehensive management plan (Albacete et al., 2004). YNP is divided into five zones, including intangible, restricted use, regulated use, extensive use, and a transition zone covering the Huaorani Reserve and settled areas (MAE, 2016c).

2.1.5. Management arrangements

YNP's management includes a team of 51, handling strategic planning, program coordination, and park control, (Bliemsrieder et al., 2011). The last management plan, revised in 2011, emphasizes participatory approaches with stakeholders and respects indigenous rights (Figure 5; Bliemsrieder et al., 2011).

In YNP, diverse indigenous groups and settlers have varied perceptions and uses of natural resources, leading to a shared management agreement with the ME in 2004 for Kichwa communities (MAE, 2016a). This includes land use and management plans updated every decade (Araya and Hubertus, 2000). Despite this, there's a system to adapt and reinforce indigenous autonomy and area protection (MAE, 2016a; Loaiza et al., 2015).

2.2. Abiotic environment

2.2.1. Geology

YNP's landscape varies from 190 m to 400 m above sea level (Bliemsrieder et al., 2011). The park's location, mainly within the Curaray Formation from the Upper Miocene, reflects its geological diversity (Barriga, 1994).

2.2.2. Hydrography

YNP lies within the Napo River basin (Barriga, 1994). The park is crossed by several rivers, including the winding Tiputini and the larger Yasuní (Barriga, 1994).

2.2.3. Climatology

YNP features a high average temperature of around 25°C and heavy rainfall, annually exceeding 3,000 mm and potentially reaching over 6,000 mm (Barriga, 1994). The climate includes high humidity at 90% and consistent cloud cover. Positioned within a Humid Tropical Climate zone (Barriga, 1994).

2.3. Communities and human activities

2.3.1. Access and infrastructure

Access to YNP is feasible via land, air, and river. From El Coca city, entry is by canoeing along the Napo, Yasuní, and Tiputini rivers. Additionally, travel from El Coca via canoe on the Napo River to Pompeya, followed by the Maxus road, offers another route (Figure 3; Pappalardo and De Marchi, 2013).

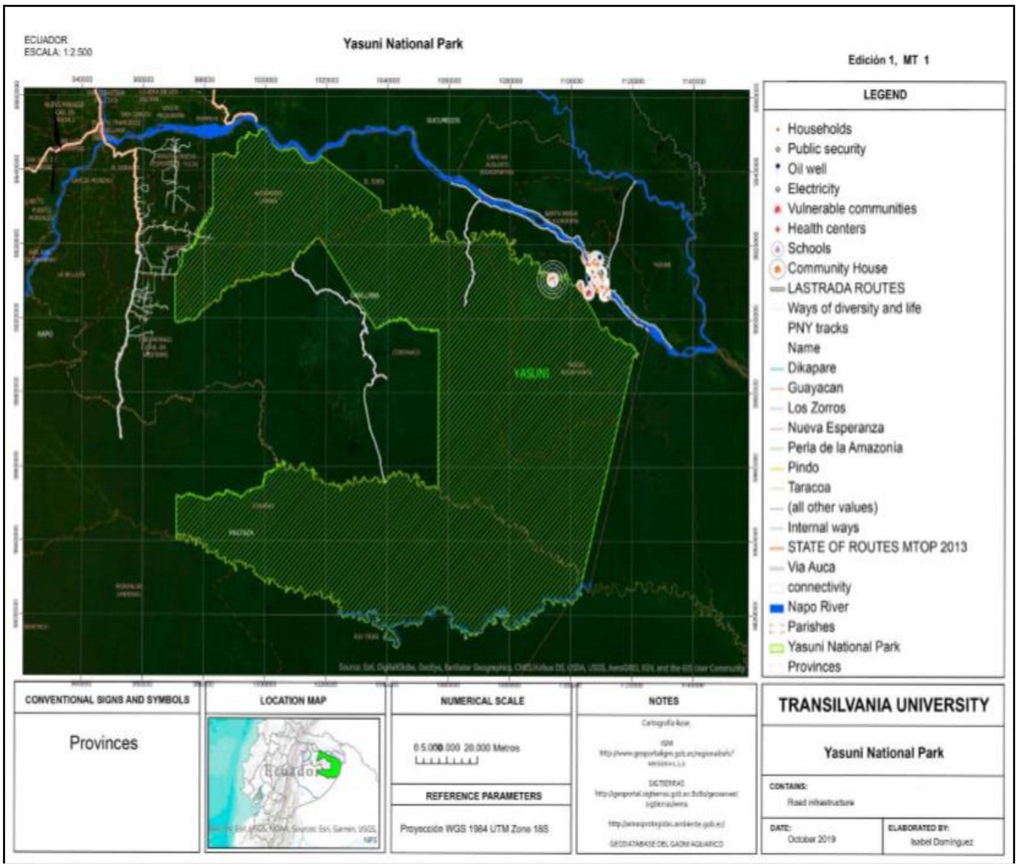

Figure 3. Access and infrastructure

Maxus Ecuador Inc. built a 140 km road in YNP for oil field access. This has significantly altered the Waorani and Kichwa communities' social structures by changing mobility and lifestyle habits (Pappalardo and De Marchi, 2013).

2.3.2. Land and Resources Ownership

PA establishment often disregarded ethnic groups' presence (Bliemsrieder et al., 2011). This led to overlaps with indigenous ancestral lands, issues with land ownership (Bliemsrieder et al., 2011).

2.3.3. Local communities

YNP is home to 16 indigenous communities, divided between eight Kichwa and eight Waorani groups, and includes the voluntarily isolated Tagaeri Taromenane. Key Kichwa communities significantly contribute to Yasunî's conservation (Bliemsrieder et al., 2011).

In Ecuador's YNP, rich in biodiversity and indigenous communities, lies the country's second-largest oil fields, but also faces threats from illegal activities like logging (Finer et al., 2009). The decision to allow oil exploitation within the park triggered a complex conflict involving environmental groups (Aguirre, 2007). Despite efforts to involve stakeholders, the park's management lacks full integration of social resilience principles, exacerbating conservation challenges (Stoessel and Scarpacci, 2021). Various studies explore the intricate relationship between local communities (Finer et al., 2009; Finer et al., 2010; Oldekop et al., 2020), and conservation pressures (Domínguez et al., 2022; Lecuyer et al., 2018). Challenges like inefficient water resource use and inadequate land management among Kichwa communities require attention (Torres et al.2018; Weckmüller et al., 2019). However, significant knowledge gaps persist in understanding the dynamic relationship between ecosystem services human well-being, and underlying drivers (Jaramillo, 2019), crucial for achieving sustainable equilibrium (Chicaiza Ortiz et al., 2022).

Local communities and indigenous groups contribute to managing PAs, with oversight from the ME (MAE, 2016a) through territorial Management Plans, submitted by communities and approved by the ME (Table 5; MAE, 2016a).

Table 5. Communities Territorial Management Plan (MAE, 2016a; MAE, 2016c)

Communities Territorial Management Plan	
1. Legal situation	Ancestral communities face the problem generated by the other invasive communities, who asked for territories and were legally recognized by ME, in 2001.
2. Use and land cover	According to the ME map (2010), 97% of the territory of the six Kichwa communities consists of native forest, with the remaining 3% comprising communal use areas.
3. Zoning of the territories	The zoning is divided into five areas: Intensive use; Damping; Tourism; Rivera protection; and maximum protection.
4. Natural resource management programs (MAE, 2016a).	Wildlife Management Control and Surveillance Environmental Education and Training Productive Management Research and Monitoring Tourism Socio-organizational Strengthening Use and Territorial Management Plan Compliance

2.3.4. Stakeholders analysis

YNP management involves collaboration among local governments, government agencies, indigenous groups, NGOs, and private sectors, coordinated by the ME, highlighting a shared responsibility beyond the ME's sole authority (Table 6; MAE, 2016a).

Table 6. Stakeholders in YNP (Bliemsrieder et al., 2011; MAE, 2012; MAE, 2016a; MAE, 2016b; PDOT, 2020)

Name	Importance (power of influencing decisions)	Area of interest	Description	Relevance
Government: ME	High	Management Administration Economic Academic	Is the supervision organism of administration and	High

		Conservation Touristic	management of the PAs in Ecuador.	
Provincial governments: Orellana and Pastaza provinces	Medium	Conservation Touristic Economic	The competence is to plan the provincial development.	Medium
Local governments: Orellana, Arajuno, Aguarico	Medium	Conservation Touristic Economic	The competence is to plan the cantonal development.	Medium
Parish governments: Curaray, Rocafuerte, Tiputini, Alejandro labaka, Cononaco, Ines Arango, Dayuma	High	Conservation Touristic Economic	The competence is to plan the Parish development.	High
Zonal Provincial and Undersecretary Directorate	High	Management Administration Economic Academic Conservation Touristic	It's a representative of the ME at the provincial level.	High
Armed forces, National Police, Marine	High	Conservation Touristic	To control and preventing the illegal trafficking of flora and fauna.	High
Indigenous nationalities: Huaoranis, Kichwa, Shuar, and country organizations	High	Conservation Touristic Economic	These groups are important and decisive in territorial planning processes and dynamic approaches with the use of the territory.	High
National and international NGOs: WCS (Wildlife Conservation Society), Yasuní Scientific Station (PUCE), Tiputini Scientific Station (USFQ)	Medium	Conservation Tourist Economic Research	These organisms are involved in development, research, and conservation programs within YNP	Medium
Private company: tourism	Medium	Economic and Conservation (Tourism)	They are tourism services companies with economic and conservation purposes	Medium
Private company: oil exploitation	Medium	Economic	They are companies that provide oil services whose purpose is economic	Medium

2.3.5. Economical activities

Oil exploitation

Since the 1960s, oil exploitation has significantly shaped Ecuador's policies and economy, being an environmental complex challenge (PDOT, 2020). YNP has had to balance its conservation role with the demands of the hydrocarbon industry, managed by PetroOriental, Repsol YPF, and Petroamazonas (operated by Petroamazonas; Papalardo and De Marchi, 2013; Figure 4).

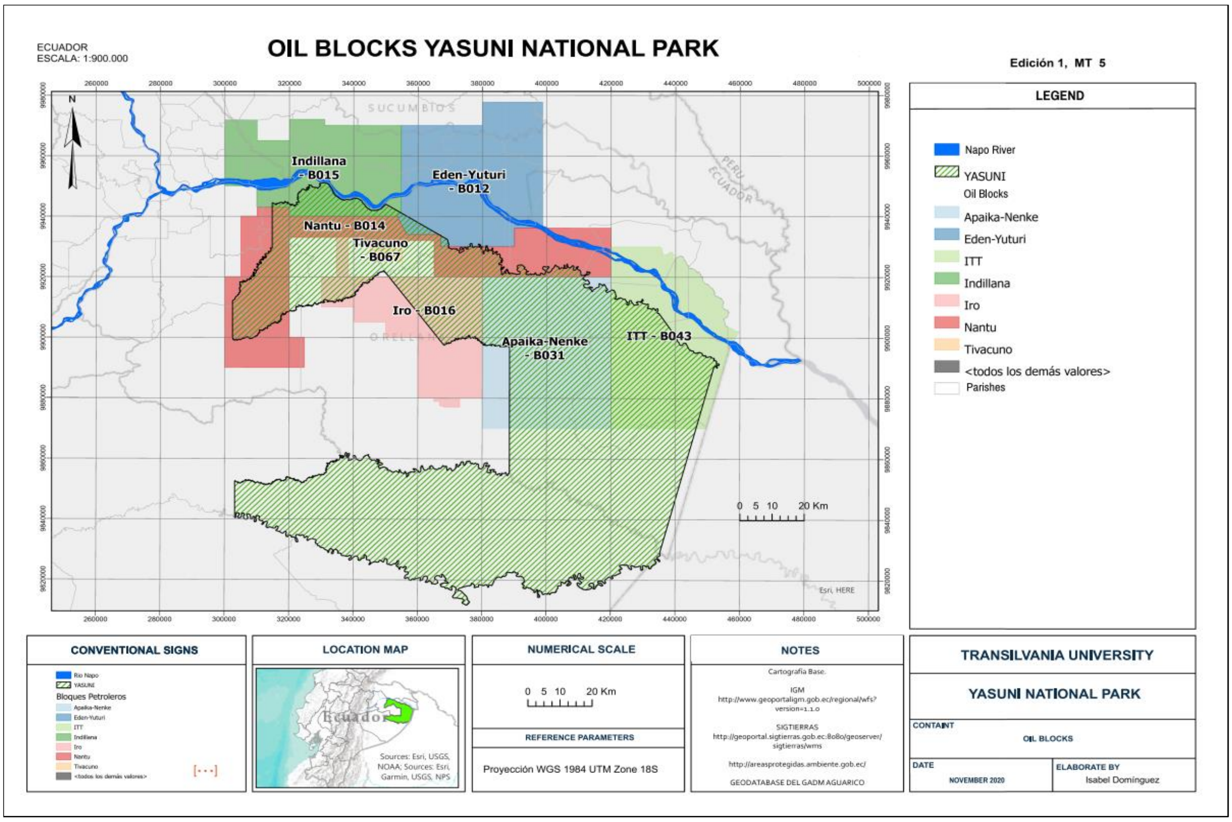

Figure 4. Oil blocks in YNP

The YNP administrative costs are financed by the State, while the projects depend on international investment funds (Bliemsrieder et al., 2011).

Tourism

Tourism in YNP began in the 1960s, (MAE, 2016a). From the first recorded 130 visitors in 2000, annual visits averaged 12,000 between 2010 and 2016. However, this number dropped to an average of 9,303 visitors from 2014 to 2022, mainly due to the COVID-19 pandemic, leading to a year-long closure of PAs from April 2021 to 2022 (Figure 5; Guzmán, 2017).

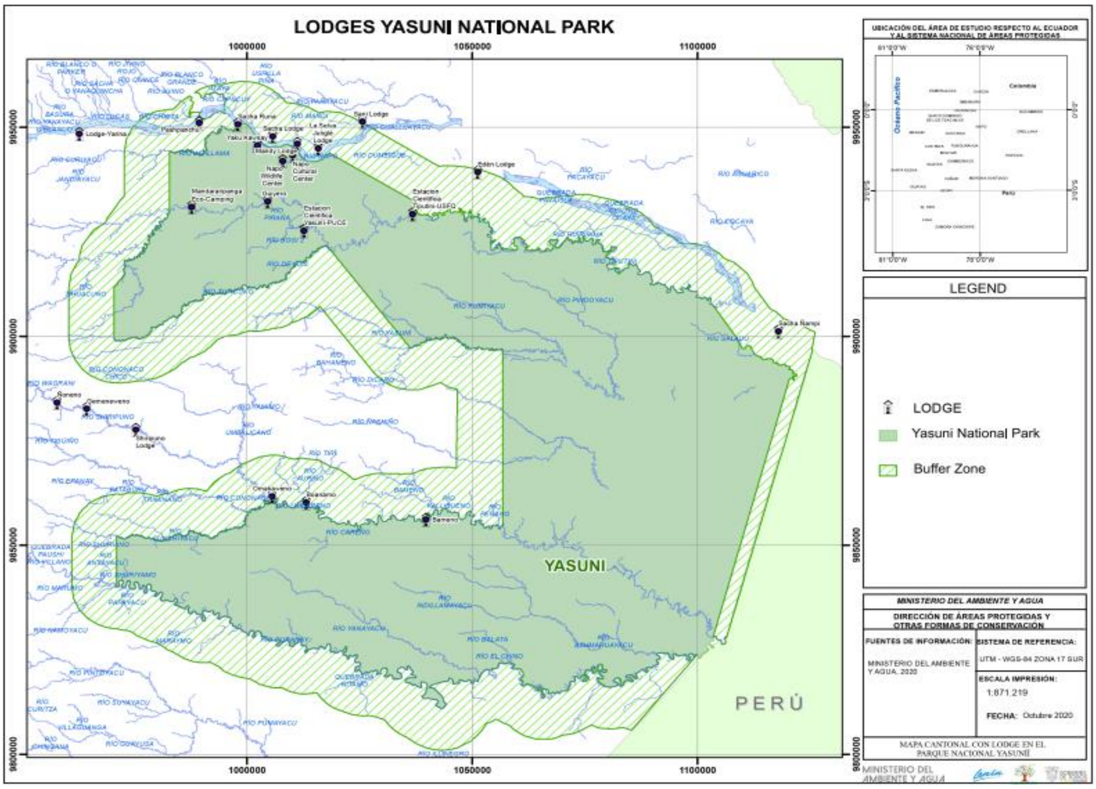

Figure 5. Lodges in YNP (MAE, 2021c)

Agriculture

Agriculture in YNP involves subsistence and commercial farming (Cueva et al., 2004). Main crops include coffee, cocoa, and corn, alongside other plantations (Anda et al., 2017). YNP management aims to regulate land use and encourage sustainable practices to optimize soil use (Bryja, 2009).

Hunting

In the YNP, communities prioritize subsistence hunting for animal protein, while settlers focus more on agriculture and livestock (Zapata-Ríos et al., 2006). Hunting is more common near the YNP (Cueva et al., 2004).

2.4. Biodiversity

2.4.1. Main habitats

In the western Amazon, notably the Yasuní region within the Napo Moist Forests and Upper Amazon Piedmont ecoregions (Bass et al., 2010). The area's forest is classified as Tropical Humid Forest, comprising four main vegetation types: firm land above hills, seasonally flooded Várzea, permanently flooded igapó forest, and swamp forest dominated by the "morete" palm (MAE, 2012b).

2.4.2. Main species

YNP hosts a vast array of species across various taxonomic groups (Romo et al., 2017). Recorded biodiversity includes 2,274 tree and shrub species, 204 mammals, 610 birds, 121 reptiles, 139 amphibians, over 268 fish, and hundreds of thousands of insects up to 2004 (Bliemsrieder et al., 2011).

2.4.3. ES in YNP

ES are vital benefits from biodiversity and ecosystems, categorized into provisioning, regulating, cultural, and supporting services (Popa et al., 2016). However, social and economic growth has impaired these ecosystems' ability to deliver such services, making their assessment and valuation crucial (Laurans et al., 2013).

Identification of ES in YNP

Ecuador possesses around 10 million hectares of ancient and secondary native forests, rich in biodiversity and ES (De Koning et al., 2011). A study in Sumaco Biosphere Reserve, near YBR, highlighting 62 ES deemed vital for local communities These services are categorized into 14 types by experts, showcasing the direct value these forests provide to indigenous populations (Figure 6; Delgado-Aguilar et al., 2017).

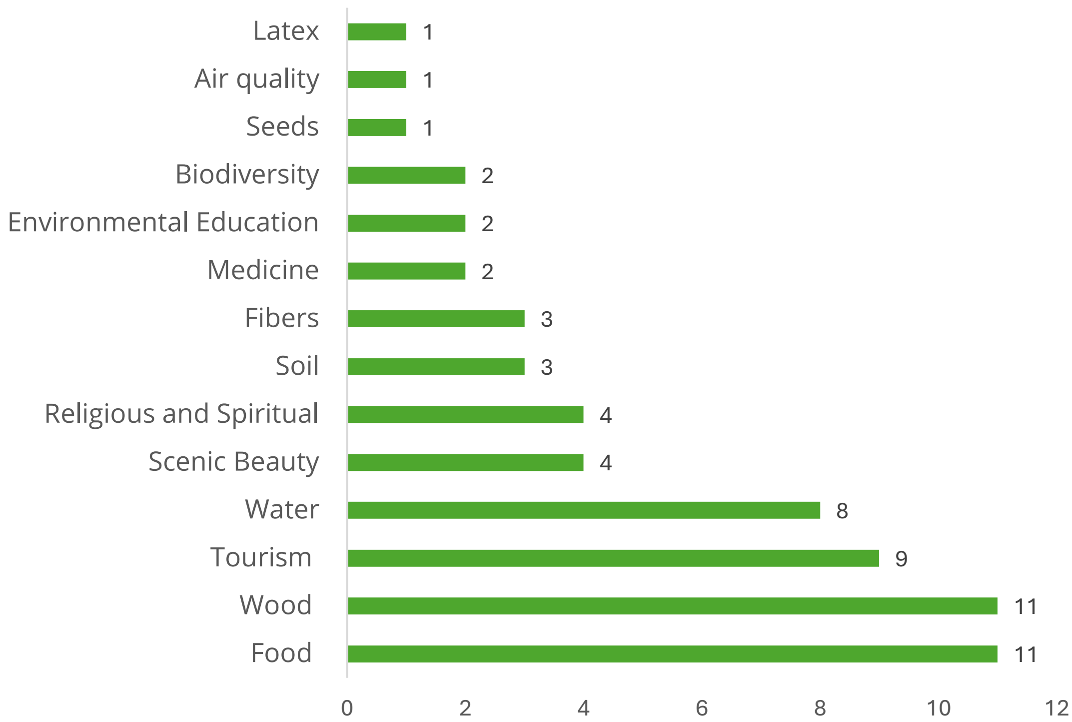

Figure 6. ES identified by experts (Delgado-Aguilar et al., 2017)

Community interviews identified food, wood, and tourism as key ecosystem services in the Amazon, with tourism viewed as a pathway to sustainable development (Delgado-Aguilar et al., 2017). Carbon sequestration was noted as an important indirect service (Walker et al., 2014). Additional services include climate regulation, cultural values, water provision, ancestral knowledge, prey access, and soil fertility (Lange, 2017).

Evaluation of ES

In Ecuador, extractive economic activities have led to biodiversity loss and deforestation (Srinivasan, 2015). The Yasuní ITT project, in 2007, had the objective of preventing oil extraction in the PNY, in exchange for conserving the forest and avoiding 400 million tons of CO2 emissions (Fierro, 2017). The funds were to support sustainable development projects (Kingsbury et al., 2019). Despite the innovative approach, the project raised less than 10% of the target, leading to the commencement of oil extraction in YNP (Lange, 2017). Concurrently, the government launched the Socio Bosque Program in 2008, offering up to $30 per hectare for forest conservation (Yánez and Granda, 2016), including Kichwa communities (Finer et al., 2009).

2.5. Ecotourism in YNP

Tourism in countries like Ecuador, can mitigate poverty by fostering sustainable models (Erskine and Meyer, 2012). Projects, especially in Kichwa and Waorani communities (Gould, 2017), are initiatives supported by international agencies and intend for eventual community ownership (Marcinek and Hunt, 2019). The Kichwa Añangu community's approach promotes environmental harmony and community-based tourism through ventures like Napo Wildlife Center and Napo Cultural Center (Renkert, 2019).

2.5.1. Main interest areas

Planning and management of the tourist activities in YNP

The YNP management plan distinguishes three scenarios for visitor access and conservation: pristine, primitive, and natural/rustic (Figure 7; MAE, 2016a).

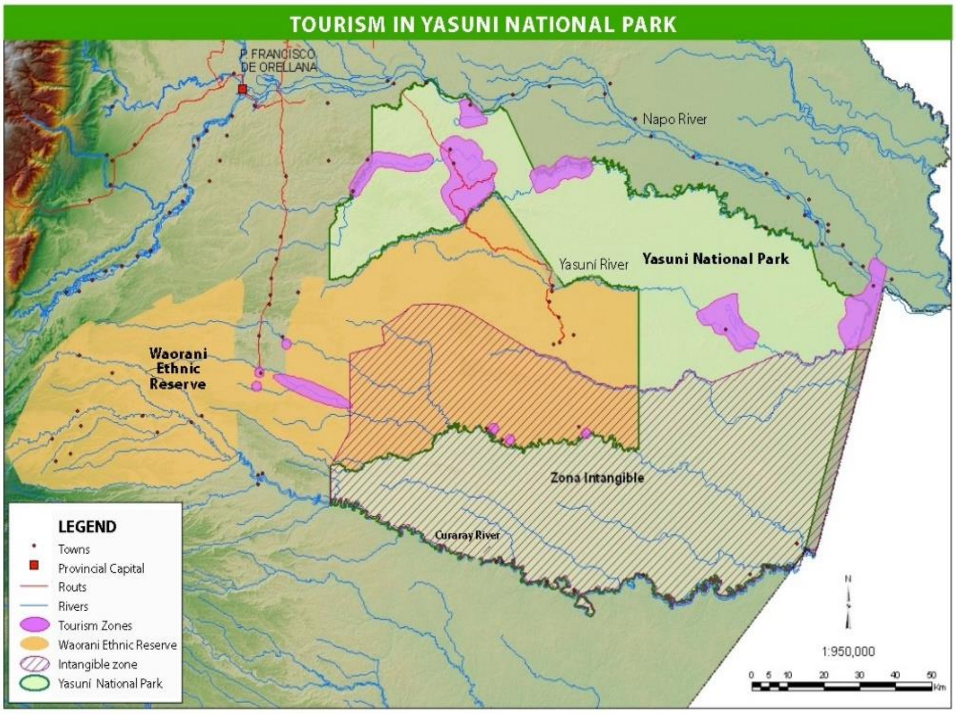

Figure 7. Tourism in YNP (MAE, 2016a)

2.5.2. Visitors profile of YNP

From 2014 to 2016, YNP's main visitors were university students aged 26 to 35 from North America and Europe, engaging in flora and fauna observation over four to five days with costs ranging from $200 to $500. Information was obtained from tour operators and the Internet (MAE, 2016a). Satisfaction levels averaged a "good" rating but showed a decline, highlighting a need for service improvement and better tourism management (MAE, 2016a).

2.5.3. Ecotourism Impacts in YNP

Ecotourism in YNP, while sustainable with proper management, risks overexploitation and damage to attractions due to unplanned development (Bliemsrieder et al., 2011). Negative impacts include illegal hunting, species trafficking, poor waste management, and risk to uncontacted peoples due to unauthorized activities and cultural acculturation (Jaramillo, 2019). Despite these challenges, Ecuador views tourism as a means to enhance local economies and prevent emigration (MAE, 2021c).

2.5.4. Eco-tourism ES in relation to local communities (benefits for local communities)

Añangu's tourism project has enabled the community to pursue local livelihood production, cultural reclamation, and environmental stewardship, shifting away from agriculture, hunting, and jobs in petroleum or abroad (Renkert, 2019). Tourism now offers improved employment opportunities, with varied salaries and access to education. Cultural tourism helps preserve identity through celebrations and traditions, educating future generations (Renkert, 2019).

CHAPTER 3. RESEARCH RATIONALE, SCOPE AND OBJECTIVES

PAs cover about 16% of the Earth's surface (Leverington et al., 2010). They serve as the primary defense against biodiversity decline and loss (Xu et al., 2019). However, managing PAs is challenging due to their complexity (Zeeshan et al., 2017), despite traditionally assuming ecosystem immobility (López and Mulero-Pázmány, 2019; Neira, 2013). An integrated, ecosystemic approach is vital, acknowledging human interdependence with natural systems (Rosales et al., 2020). PAs, face pressures leading to management conflicts (Hole et al., 2011). An adaptive management paradigm is needed, aiming for transformative changes (Torregroza et al., 2014).

Adaptive management in PAs emphasizes collaborative strategies (Agrawal, 2000), involving joint actions at national and international levels (Neira, 2013). In Latin America and Ecuador, socio-ecological interactions are crucial (Lecuyer et al., 2018). Adaptive management in Ecuador seeks to integrate ancestral knowledge and socio-ecological understanding into PA management, aiming for governance strengthening and flexible solutions tailored to local realities (Neira et al., 2022).

3.1. Research Aim

YNP is confronted with complex, multi-dimensional challenges, with a significant gap in adaptive management research for the region, specifically YNP, the general research objective was to analyze the social-ecological system of YNP, on the way to adaptive management planning. In this sense, the study approaches PAs as dynamic systems with their socio-ecological environment, emphasizing learning and resilience.

3.2. Research Objectives

The specific objectives which were approached as methodological steps to get results and to achieve the goal of this work were the following:

i) To assess the current status of the YNP management by measuring its effectiveness.
ii) To generate a description of the system, and to identify the most relevant relationships which define the system of YNP.
iii) To develop a description of the dynamics of the situation and to establish a better understanding of the status of the conservation targets and identify existing and potential stresses, risks, and threats.
iv) To analyze existing strategies and generate recommendations to improve target functionality, and reduce threats, vulnerability, and risks.

3.3. Methodological approach

3.3.1. Methodological framework: MARISCO approach

Adaptive management uses a systemic approach (Romero et al., 2018). The Adaptive MARISCO methodology, utilizes an ecosystem-based risk management approach, drawing from the

Conservation Measures Partnership's Open Standards (Ibisch and Hobson, 2014; Romero et al., 2018; Table 8). MARISCO serves as a planning toolbox for analyzing ecosystems (Ibisch and Hobson, 2014). It has been globally applied in diverse APs (Ibisch and Hobson, 2015). In Ecuador, MARISCO has been implemented in two specific PAs, aiming to enable adaptive, sustainable natural resource management (Frampton, 2019).

The Adaptive MARISCO methodology is cost-effective, versatile for various systems and scales, and supports both quantitative and qualitative data (Ibisch and Hobson, 2015). The method involves spatial analysis, ecosystem diagnosis, and planning for adaptive conservation, structured into four main phases (Ibisch and Hobson, 2015; Table 7 and Figure 8).

Table 7. Overview of the four major MARISCO phases (adapted after Ibisch and Hobson, 2014)

Phase	Name	Objective	Comments
I	Preparation and initial conceptualization	To conduct an Ecosystem Diagnostic Analysis (EDA).	This is the main object of the present study.
II	Systematic vulnerability analysis	To analyze the situation and identify existing and potential stresses, risks, and threats.	These two phases of the MARISCO methodology were not included in the present study.
III	Comprehensive evaluation, prioritization, and strategy formulation	To analyze existing strategies to improve target functionality, reduce threats, vulnerability, and risk.	
IV	Implementation and (non-) knowledge management	To implement the strategic plan, knowledge management, and evaluation of the process.	

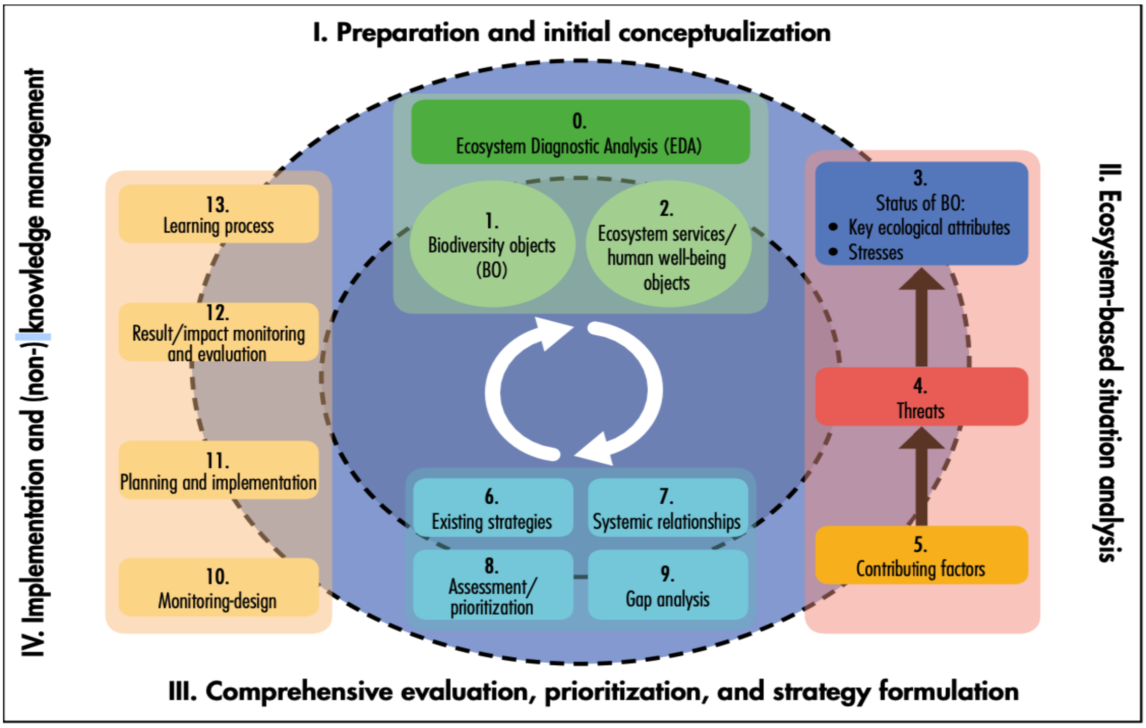

Figure 8. MARISCO cycle diagram including all steps and processes (Rosales et al., 2020)

3.3.2. METT

Different sources (Leverington et al., 2008; Stolton et al., 2007) recommend METT as the best tool for tracking progress over time in individual PA or in groups. METT is a rapid assessment based on a scorecard questionnaire that includes all six elements of management cycle (Leverington et al., 2008). Global Database on PA management evaluation provides information regarding a total number of 3,184 evaluations using METT (GDPAME, 2020), all over the world. In the last decade, the assessments have been implemented by local PAs agencies and authorities (Stoll-Kleeman, 2010) as requirements for countries to report to the CBD on Aichi Target 11 (CBD, 2010; Moreaux et al., 2018). Numerous scientific studies used METT; China (Quan et al., 2011), Bhutan (Lham et al., 2019), Iran (Kolahi et al., 2013), Amazon basin (Nolte and Agrawal, 2013), KwaZulu - Natal region (Goodman, 2003), Carpathian region (Papp, 2011), or Mongolia (Namsrai et al., 2019). Based on the data collected using METT, many other studies evaluated the way PAs management effectiveness has changed since the METT methodology was first used (Coad et al., 2015); the scores for overall METT assessment increased as a consequence of better decision making arrangements (Geldmann et al., 2015); despite the development of new assessment needs, especially related to conservation effectiveness (Woon and Abdullah, 2019) or social impact assessment (Jones et al., 2017), the management related assessment should continue (López-Rodríguez and Rosado, 2017). There are also recognized constraints and weaknesses of METT (MacKinnon and Higgins-Zogib, 2006); METT relies largely on multiple-choice questions and there is also a clear risk of managers providing an overly optimistic picture of the strengths of management (Dudley et al., 2007).

3.3.3. Implementation of MARISCO methodology for YNP – data collection and analysis

According to the guidelines for MARISCO methodology (Ibisch and Hobson, 2014; Schick et al., 2019), the research was conducted using primary data from interviews and focus groups done in the field, but also secondary data collected through bibliographic research. Secondary data collection (between February and June 2022) was done through a desktop study; information on the forest ES in YNP: types (e.g. Bliemsrieder et al., 2011; Oldekop et al., 2012; Portalanza et al., 2019), dynamics and associated risks both from environmental (e.g. Oldekop et al., 2012; Suárez et al., 2012) and social perspective (e.g. Domínguez et al., 2022; Oikonomakis, 2020; Oldekop et al., 2012; Torres et al., 2018).

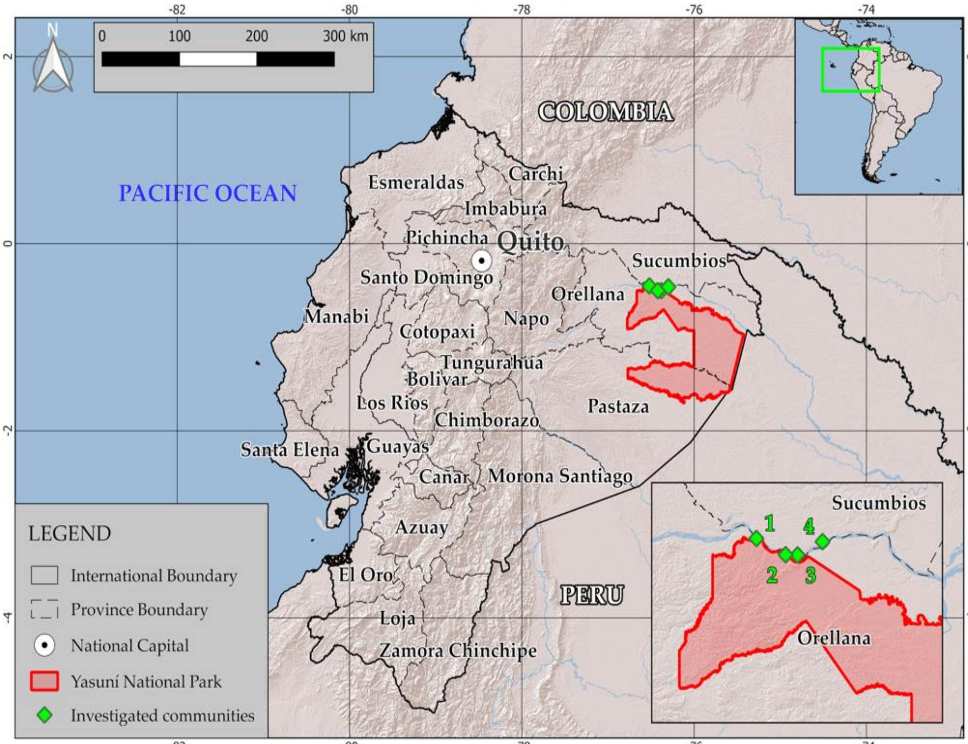

Figure 9. Study area - location of the investigated communities (1 – Indillama, 2 – El Pilche, 3 – Añangu, 4 – Sani Isla) (Domínguez-Gaibor et al., 2023)

In June 2022 over 10 days, research was conducted along the Napo River at the edge of YNP, focusing on the Kichwa nationality and including communities like Añangu, Sani Isla, El Pilche, and Indillama. The study aimed to understand local perspectives and challenges, using interviews and focus groups based on identified risks (Figure 9, Domínguez et al., 2022).

The following steps were taken:

1. Interviews with YNP management team members, a local guide, and community leaders helped identify the main risks to PA management and refine survey items on ecosystem services and drivers of forest ecosystem change (Snijders, 1992).
2. In June 2022, 57 semi-structured interviews (de Singly et al., 1998) were conducted with community members from Añangu, Sani Isla, El Pilche, and Indillama within YNP. These interviews aimed to understand changes in ecosystems and their effects on communities, focusing on their experiences and perceptions regarding conservation and ecosystem alterations. Interviews were carried out by a researcher and a Kichwa guide/translator in community centers or respondents' homes.
3. In June 2022, four focus groups with local communities in YNP discussed land use changes, threats, and adaptation efforts (Ibish and Hobson, 2014). In these sessions identified major risks and key stakeholders, clarifying interview uncertainties and mapping stakeholder relationships, with an emphasis on open, unbiased communication.
4. Fild visit (June 2022): bibliographical information found was verified and contrasted using field visits: during field visits, the above local communities focus groups were organized.

5. In June 2022, a focus group with YNP's leadership reviewed study findings and discussed key conservation threats and relevant programs. This session documented insights to refine the study results.
6. Data collected through the interviews, as well as the transcripts from the conclusive workshop were analyzed using qualitative content analysis (de Singly et al., 1992; Hsieh and Shannon, 2005). Based on the key informant interviews as well as the bibliographic research (Tovar-Tique et al., 2021; Vezina et al., 2020; Warrior et al., 2022) a grid of codes/themes with four categories and several sub-categories was developed even before structuring the survey (see Table 8).

Table 8. Themes used for the qualitative content analysis (analysis grid)

Categories	Sub-categories
Benefits	Wood
	Water
	Food
	Different other materials for a good life
	Security
	Health
	Good social relations
	Cultural identity
	Biodiversity
	Climate regulation
	Recreation and ecotourism
Changes in forest	Forest surface
	Forest species
	Other forest features
Forest changes drivers	Direct
	Indirect
	Relationship between drivers
	Evolution of forest change drivers over time
Expectations	Opportunities
	Risks

After analyzing interviews and focus groups, new themes were added, deepening insights into ES, human well-being, risks, and drivers for SESs. Analysis used interview counts, reflecting group consensus, to create a conceptual model mapping stakeholder relationships and their interconnectedness.

3.3.4. METT implementation for YNP – data collection and analysis

To achieve the study's goal, a survey using a questionnaire based on the METT methodology (Stolton et al., 2007; Stolton and Dudley, 2016), was conducted at YNP in the summer of 2018. The questionnaire had two sections: basic information about the NP and a 30-question scorecard covering six evaluation elements, with scores ranging from 0 (poor) to 3 (excellent). Additionally, six supplementary questions addressed specific management and community impact themes. The survey was completed during a four-hour face-to-face session with the YNP manager and five management team members. The data were compiled in Excel, with evaluation scores presented.

4.1. YNP management effectiveness

4.1.1. Overall Management Effectiveness

The METT analysis of YNP evaluated six elements against their maximum compliance standards, presenting individual compliance levels as percentages (Figure 10). The 'context' element scored the highest compliance at 83%, assessing aspects like legal status and land use regulations. Conversely, the 'inputs' element had the lowest compliance at 54.2%, evaluating factors such as staff numbers, capabilities, budget, and equipment.

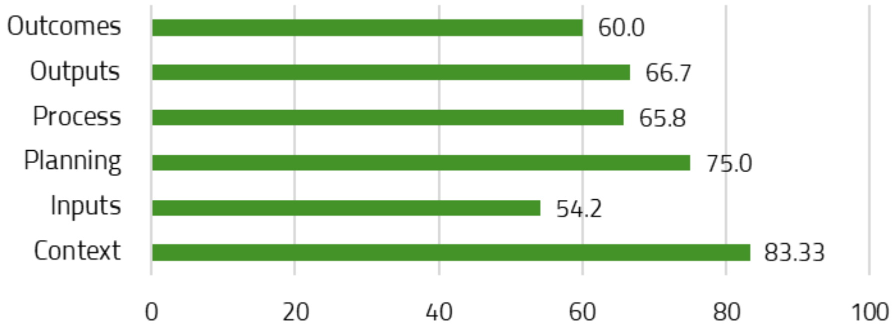

Figure 10. Average evaluation indices (%) YNP

YNP's METT assessment results align with those of Ecuador's other National Parks (NPs), indicating similar management effectiveness levels across the country (Negru et al., 2020). Legal status and regulations were well-received, leading to high 'context' scores, while planning elements were also highly rated, aside from Sangay NP (Margules and Pressey, 2000). However, 'inputs' related to resources were the weakest across all NPs, except for Galapagos NP (López-Rodríguez and Rosado, 2017). Sangay, Machalilla, and Cotopaxi NPs were noted for having significantly fewer resources (Vellak et al., 2009). Addressing funding shortages and improving monitoring and evaluation systems were suggested as ways to enhance management effectiveness in Ecuador's NPs, recognizing underfunding as a systemic issue in PA management globally (Lham et al., 2019; Quan et al., 2011).

Table 9. Indices for evaluation elements and overall management effectiveness (Negru et al., 2020)

Park	Evaluation elements indices (%)						Management effectiveness indices (%)
	Context	Planning	Inputs	Process	Outputs	Outcomes	
Yacuri	100	83.3	66.7	73.7	83.3	80.0	76.0
Cayambe – Coca	100	75.0	50.0	55.3	83.3	60.0	61.5
Sangay	66.7	41.7	37.5	42.1	33.3	30.0	40.6
Llanganates	100	83.3	58.3	63.2	50.0	70.0	66.7
Cotopaxi	83.3	66.7	50.0	52.6	83.3	50.0	57.3
El Cajas	100	100	75.0	71.1	83.3	100	81.3

Podocarpus	83.3	75.0	62.5	68.4	83.3	40	66.7
Yasuní	83.3	75.0	54.2	65.8	66.7	60.0	64.6
Sumaco Napo – Galeras	100	66.7	62.5	73.7	100	80.0	74.0
Galapagos	100	100	100	97.4	100	100	99.0
Machalilla	83.3	66.7	45.8	52.6	66.7	60.0	56.3
Río Negro Sopladora	50.0	25.0	0.0	5,3	0.0	40.0	12.5

The METT assessment by Negru et al. (2020) showed variation in 'outputs' and 'outcomes' elements across Ecuador's National Parks, with scores ranging from 33.3% for Sangay NP to 100% for Galapagos NP in 'outputs', and from 30.0% for Sangay NP to 100% for Galapagos NP in 'outcomes' (Table 10).

4.1.2. Management strengths and weaknesses

Once the METT questionnaire was applied, the following scores were obtained for each of the topics assessed:

Table 10. The given scores for different evaluation elements by using METT

Element of Evaluation/ Maximum Possible Score	Actual scores given
1. Legal status: (*Context/3)*	3
2. PA regulations (*Context/3)*	2
3. Law enforcement (*Input/3)*	2
4. PA objectives (*Planning/3)*	2
5. PA design (*Planning/3)*	3
6. PA boundary demarcation (*Process/3)*	2
7. Management plan (*Planning/6)*	4
8. Regular work plan (*Output/3)*	2
9. Resource inventory (*Input/3)*	2
10. Research (*Process/3)*	2
11. Resource management (*Process/3)*	2
12. Staff numbers (*Input/3)*	2
13. Human resources management (*Process/3)*	2
14. Staff training (*Input/3)*	2
15. Current budget (*Input/3)*	2
16. Security of budget (*Input/3)*	1
17. Management of budget (*Process/3)*	2
18. Equipment (*Input/3)*	2
19. Maintenance of equipment (*Process/3)*	2
20. Education and awareness (*Process/3)*	2
21. State and comm. Neighbors (*Process/3)*	2
22. Indigenous people (*Process/3)*	2

23. Local communities (*Process/5)*	2
24. Visitor facilities (*Outputs/3)*	2
25. Commercial tourism operators (*Process/3)*	2
26. Fees (*Inputs/3)*	0
27. Condition of values (*Outcome/4)*	2
28. Protection systems (*Output/3)*	2
29. Economic benefits (*Outcome/3)*	2
30. Monitoring and evaluation (*Process/3)*	2

In the METT assessment for YNP, legal establishment and design received high scores, indicating effective national-level policy implementation. However, law enforcement scores were lower, suggesting a need to enhance regulatory application within the park (Quan et al., 2011). The condition of YNP's values scored two out of four. This suggests that a single question on biological outcomes in the METT may not adequately reflect the ecological condition's complexity within a PA (Geldmann et al., 2015).

In the METT assessment for YNP, visiting fees and budget management were identified as areas needing improvement (Table 11), (Negru et al., 2020). A key challenge across Ecuadorian NPs, including YNP, is managing relationships with local communities, with an average score of 1.3 (Negru et al., 2020). Enhancing community and indigenous participation in decision-making (Hayes, 2006; Schwartzman et al., 2000; Wei et al., 2018).

This study aligns with global METT surveys from 2007 and 2015 (Dudley et al., 2007; Namsrai et al., 2019; Papp, 2011), showing high scores in legal status and PA design but lower scores in value condition, budget issues, and relationships with indigenous people and local communities. The 2006 survey highlighted strengths in legal status and PA demarcation, but weaknesses in education, budget, and community relations. A notable 2015 (Geldmann et al., 2015), finding indicated significant improvements over time in legal status and management plans, while changes in value conditions remained minimal.

4.2. SES analysis of YNP

4.2.1. Relevant stakeholders

YNP's management involves a complex interplay of many actors (Bliemsrieder et al., 2011; Zárate, 2013), with the ME coordinating conservation efforts and regulatory enforcement (Figure 14; Mestanza-Ramón et al., 2020; Zárate, 2013). Key ME areas, are responsible for biodiversity conservation within PAs, (Bliemsrieder et al., 2011; Mestanza-Ramón et al., 2020). Academic contributions come from universities (Romo et al., 2017). Additionally, local and international organizations, support development projects (Figure 11). Local communities, integral to ecosystem conservation, align their development plans with YNP’s Management Plan (Pozo et al., 2016). While, the presence of oil and tourism companies in and around YNP underscores the challenge of balancing conservation with economic activities (Pozo et al., 2016).

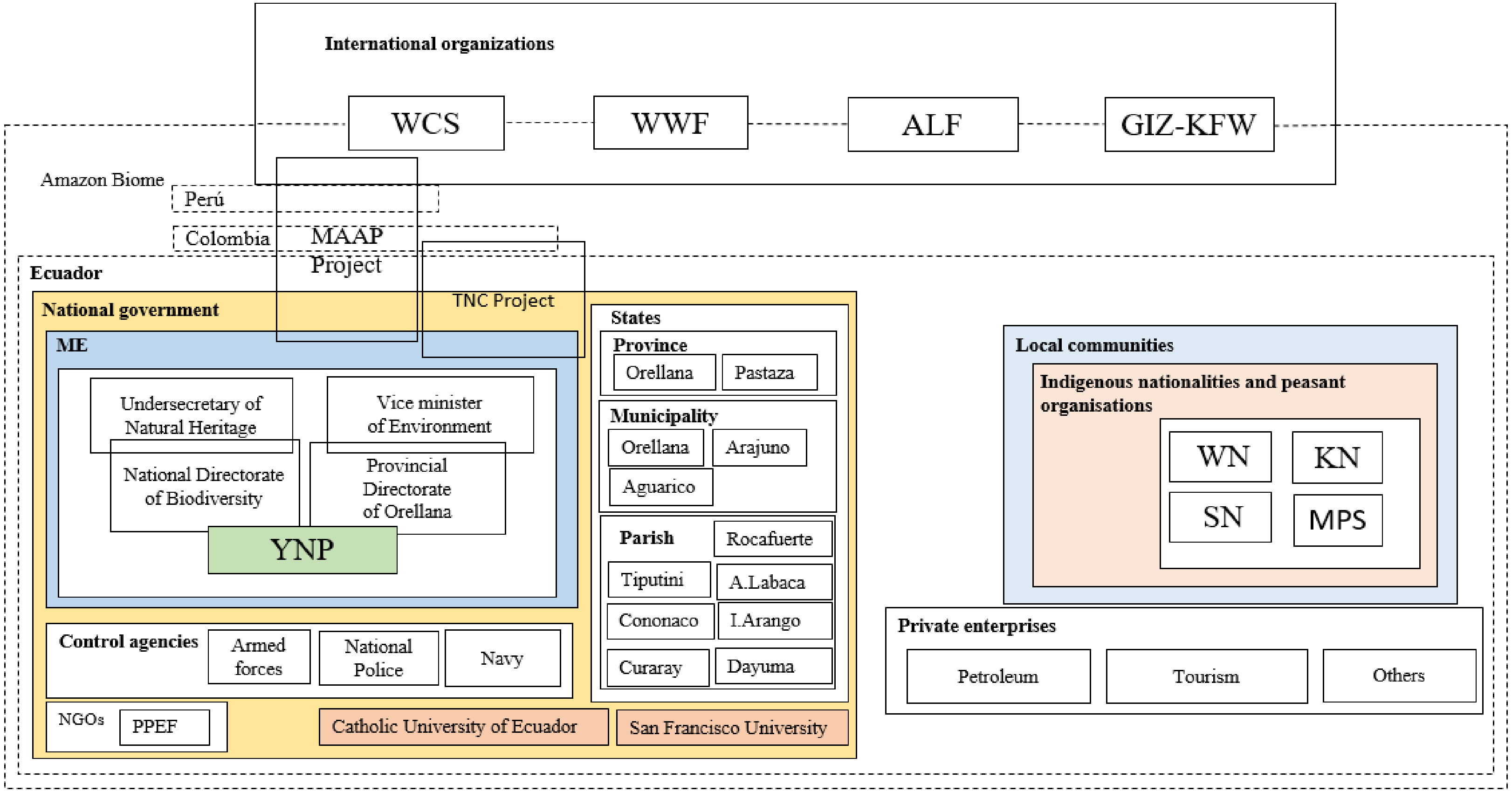

Figure 11. Diagram of the main stakeholders linked to YNP. **ALF -** Alejandro Labaka Foundation; **GIZ -** German Society for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit); **KFW -** German Development Bank (Kreditanstalt für Wiederaufbau); **KN -** Kichwa Nationality; **MAAP -** Monitoring of the Andean Amazon Project; **ME -** Ministry of Environment; **MPS –** Mestizos ; **KN-** Kichwa Nationality; **MAAP -** Monitoring of the Andean Amazon Project; **ME -** Ministry of Environment; **MPS -** Mestizos Peasants and ettlers; **PPEF -** Populorum Progressio Ecuadorian Fund; **SN -** Shuar Nationality; **TNC -** The Nature Conservancy; **WCS -** Wildlife Conservation Society; **WN -** Waorani Nationality; **WWF -** World Wildlife Fund; **YNP -** Yasuní National Park

Kichwa communities around YNP reveal difficulties in engaging with park management due to resource limitations and language barriers, viewing oil companies as more influential than tourism, which they see as a preferable alternative. YNP's management aims to better involve communities in decision-making and improve project coordination among various stakeholders, including international organizations, the government, and locals. These interactions influence YNP's ecosystem services, conservation efforts, and economic activities (Figure 11).

4.2.2. Key ecological attributes

YNP is recognized as one of the most biodiverse areas globally, with unique and valuable ecological attributes identified through bibliographic research.

High Biodiversity

YNP is recognized for its exceptional biodiversity (Dietz and Adger, 2002; Finer et al., 2009). The park hosts 655 tree species per hectare, and supports the world's highest insect population density, with about 100,000 species per hectare (Bass et al., 2010; Hoorn, 2006). Factors contributing to this biodiversity include the convergence of various biogeographic regions (Gomez-Salazar et al., 2012), fostering unique ecosystems and species diversity (Hockings et al., 2006; Hoorn, 2006).

Endemic species

YNP harbors a wealth of endemic species, emphasizing its ecological uniqueness and evolutionary significance (He and Hubbell, 2011). These species serve as vital indicators of the ecosystem's health and underscore the critical need for conservation efforts to preserve the park's biodiversity (Wei et al., 2018). Highlighted by the Yasuní-ITT Initiative megadiverse (Tapia-Armijos et al., 2017), the park's remarkable biological and cultural diversity, along with its indigenous populations' voluntary isolation, accentuates its global conservation value (Mestanza-Ramón et al., 2020). Yasunî's biodiversity showcases its prehistoric preservation and the importance of protecting these ecosystems (Finer et al., 2009).

Emblematic species

YNP, one of Earth's most biodiverse regions, hosts numerous iconic species, each serving as vital indicators of ecosystem health (Krause and Zambonino, 2013): *Trichechus inunguis* and *Inia geoffrensis* (Dietz and Adger, 2002; Gomez-Salazar et al., 2012); *Harpia harpyja* and *Pteronura brasiliensis* (Rampheri et al., 2022; Galacatos et al., 2004); *Corallus hortulanus* and *Panthera onca*, (Galacatos et al., 2004; Sierra et al., 2002). Dendrobates species (poison dart frogs), (Galacatos et al., 2004).

Amazon rainforests

The Amazon rainforest, vital for global climate regulation, absorbs carbon dioxide and produces oxygen (Loki, 2019), thereby acting as a crucial climate stabilizer (Cordero and Koeppen, 2021; Etchart, 2022). Yasuní plays a key role in climate regulation by mitigating greenhouse gas concentrations (Dornhoff et al., 2019; Etchart, 2022), and slowing global warming (Cheng et al., 2013; Walker et al., 2014). Moreover, the rainforest sustains indigenous communities around YNP, providing essential SE (Weckmüller et al., 2019).

Endangered species

Ecuador's extensive infrastructural development around PAs leads to habitat fragmentation, placing significant pressure on biodiversity (Andrade-Núñez and Aide, 2020). Notably, 72% of Ecuador's endemic vascular plants and about 10% of its threatened amphibian species are unprotected (Cuesta et al., 2017; Ortega-Andrade et al., 2015). Yasuní, a haven for endangered species like the Amazon River dolphin, giant otter, and jaguar, underscores the park's critical role in species protection (Cuesta et al., 2017; Esquivel-Muelbert et al., 2019; Fadrique et al., 2018; Lippi et al., 2019).

However, threatened species are an important ecological attribute of YNP for several reasons: Indicators of biodiversity (Sierra et al., 2002); keystone species (Kleemann et al., 2022); ES (Kleemann et al., 2022; Mestanza-Ramón et al., 2020); Cultural and Economic value (Mestanza-Ramón et al., 2022).

Threatened species are vital for the park's ecological integrity and the well-being of communities. Ecuador ranks second globally in threatened species, harboring 2,501 across various groups, highlighting urgent conservation needs (IUCN, 2022). Biodiversity loss drivers include land use changes, invasive species, overexploitation, and pollution, emphasizing the importance of safeguarding these species for the ecosystem's and communities' future health and economy (Buytaert et al., 2006; Roy et al., 2018).

Indigenous communities

Indigenous and local communities are vital to biodiversity conservation (Welch and Coimbra Jr., 2021). Their unique knowledge and active participation are key to YNP's ecological and conservation efforts for several reasons (Monterroso, 2006).

Traditional knowledge and practices: They have a profound knowledge of the ecosystem and the species that inhabit it (Taylor et al., 2022). This knowledge and practices can contribute to the development of effective conservation (Kimerling, 2006; Mestanza-Ramón et al., 2020).

Sustainable resource use: They depend on the park's resources for their subsistence (Marx, 2010). These practices can help ensure the long-term sustainability of the ecosystem (Benites-Lazaro and Mello-Théry, 2019; Loaiza et al., 2015).

Cultural importance: The communities of YNP possess a unique cultural heritage closely linked to the biodiversity of the region (Muñoz, 2017).

Land management: The communities of YNP have a long history of sustainable land and resource management (Risiro, 2021). Their traditional land use practices, such as agroforestry and selective logging, can help maintain ecosystem health and productivity (Suárez et al., 2012).

Indigenous communities are integral to Yasuní National Park's sustainability, contributing valuable ecological and cultural insights (Risiro, 2021; Wei et al., 2018). Including their environmental management practices in secondary education can foster a culture of conservation and sustainable resource use (Kolahi et al., 2013; Negru et al., 2020; Risiro, 2021).

Carbon storage

Carbon storage refers to the ability of an ecosystem to absorb and store carbon from the atmosphere (Arellano, 2023). Trees and other vegetation in the park absorb carbon dioxide from the atmosphere during photosynthesis and store it (Cheng et al., 2013).

The park's ability to store carbon is critical to mitigating global climate change (Arellano, 2023; Pozo et al., 2016). By protecting the park's forests and allowing them to continue to store carbon (Lippi et al., 2019).

In addition, the park's carbon storage has economic and social benefits for local communities (Cheng et al., 2013; Morán et al., 2016). Carbon stored in the park can be traded on international carbon markets as a form of emissions offset (Cheng et al., 2013; Rampheri et al., 2022).

4.2.3. ES and human wellbeing

Respondents highlighted the critical importance of surrounding forests as a steady food source and for health benefits, particularly through medicinal plants, underscoring the forests' role in community well-being (Figure 12). The benefits related to food and health for local communities were mentioned in numerous studies (Ouko et al., 2018; Rampheri et al., 2022; Vezina et al., 2020; Wei et al., 2018) and the knowledge of YNP communities in the matter of medical use of different flora species is also confirming studies done in the past (Arias et al., 2019; Renkert, 2019; Weckmüller et al., 2019).

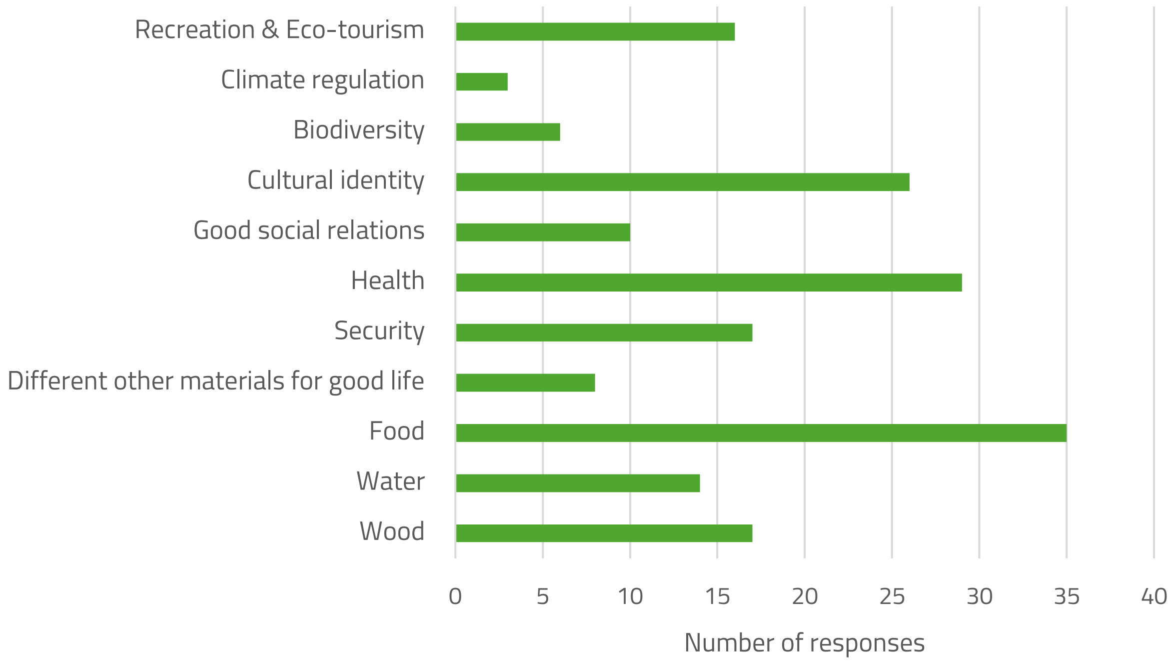

Figure 12. The main forest ecosystem benefits identified by respondents in Kichwa communities and the number of responses

Respondents highlighted cultural identity, particularly the role of forest isolation in qualifying individuals for spiritual leadership, as a crucial benefit (Oikonomakis, 2020), aligning with studies on the Kichwa community's cultural practices (Chicaiza Ortiz et al., 2022; Heredia-R et al., 2020; Jaramillo, 2019).

4.2.4. Drivers influencing the dynamics of the SESs

i) Identification of drivers influencing the forest ecosystem dynamics

YNP faces numerous threats impacting its forest ecosystems, including vegetation cover loss, water body changes, riparian forest reduction, groundwater depletion, and soil erosion (MAE, 2016b). Indirect effects such as loss of fish habitats and altered forest and agricultural lands also pose challenges (Espinosa, 2013; Finer et al., 2009; Suárez et al., 2012). Key factors affecting the SES include deforestation, land use changes, land degradation, and biodiversity loss, driven by direct factors like petroleum development, infrastructure, and small-scale agriculture, as identified by community interviews and focus groups (see Figure 12).

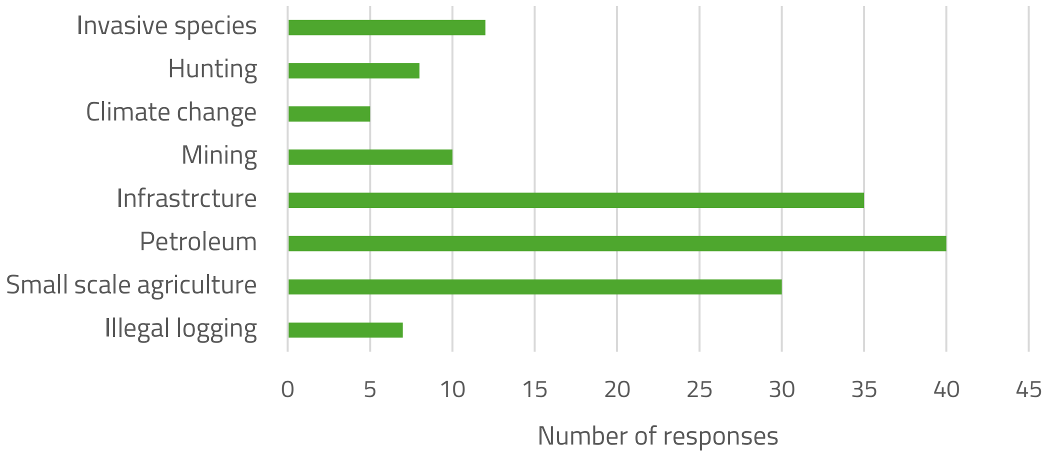

Figure 13. Direct drivers for forest ecosystem change reported in the Kichwa community and the number of responses

Also, the results of the interviews indicated that land governance and promotion of extractive activities by the state, poverty, and migration are considered the most important indirect drivers for change (see Figure 13).

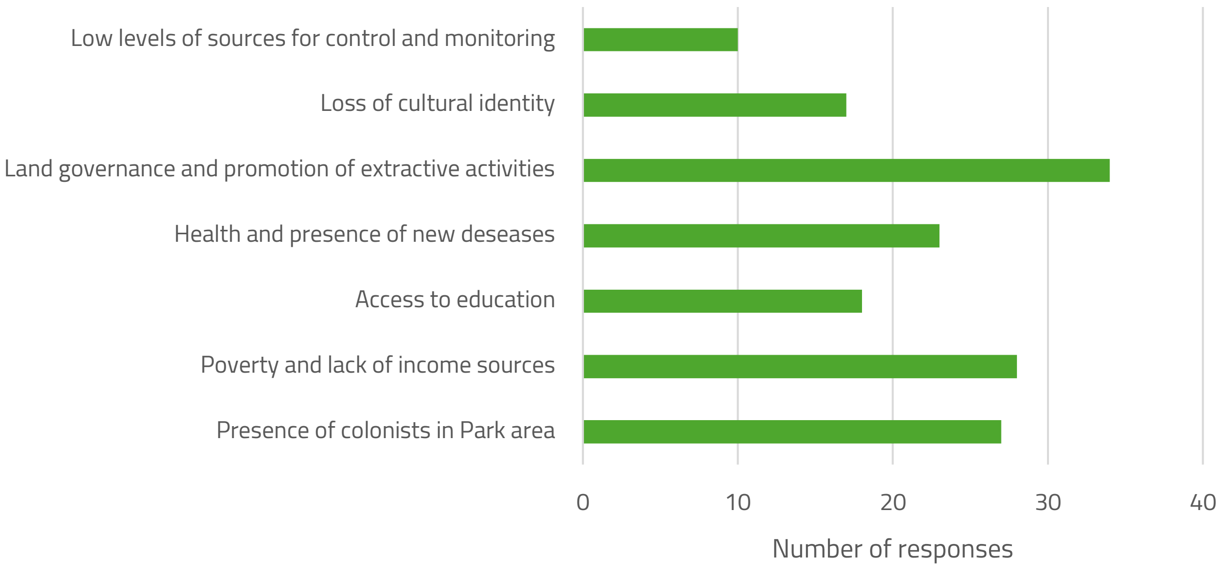

Figure 4. Indirect drivers for forest ecosystem change reported in the Kichwa community and the number of responses

ii) Description of direct drivers for forest ecosystem disturbance

Deforestation in YNP, mainly from oil extraction and related infrastructure, has impacted about 850 hectares (www.maaproject.org), threatening its diverse habitats and species. These activities risk significant biodiversity loss and ecosystem instability (Pozo et al., 2016; Suárez et al., 2012; Thieme and Hettler, 2018; Vanacker et al., 2018).

a) Oil exploitation

Since its establishment in 1979, YNP, has faced significant socio-environmental challenges (Bliemsrieder et al., 2011; Tapia-Armijos et al., 2017). It overlaps with the Ethnic Territory of the Waorani Nationality and areas designated for voluntarily isolated indigenous peoples, such as the Tagaeri Taromenane, protected within the Intangible Zone established in 2007 against extractive activities (Thieme and Hettler, 2018). Despite these protections, oil exploitation, starting in the 1980s and expanding post-2013 after the Yasuní ITT Initiative's failure, has advanced into remote northeastern areas of the park (Finer et al., 2010; Marx, 2010). The management of environmental pollution from oil activities varies by location (Dornhoff et al., 2019; Kaspari et al., 2014), and has seen both improvements due to technological and regulatory advancements (Krause and Zambonino, 2013), and increases due to heightened oil demand and extraction intensity, particularly in less regulated Amazonian regions (Etchart, 2022; Taylor et al., 2022).

Communities around YNP don´t view deforestation as a significant risk unless it involves colonists settling in the buffer zone for agriculture (claiming the land; Thieme and Hettler, 2017), which raises concerns about land rights and insufficient benefits from oil drilling on their land (Gilbert, 2017). The YNP management team acknowledges oil drilling as a major risk but believes its development is currently manageable.

b) Infrastructure development

Oil drilling activity determined the development of the transportation infrastructure with uncontrolled effect on biodiversity (Suárez et al., 2012), forest cover (McCracken and Forstner, 2014), and social dynamics of local indigenous groups (McCracken and Forstner, 2014; Suárez et al., 2012).

Respondents indicate that oil-related infrastructure in Yasuní National Park facilitates access, aiding community mobility but also enabling settlers to encroach on protected areas. This increases the risks of settlement and agricultural expansion. While the direct impact on forests is seen as limited, indirect effects on land use changes are considered significant.

c) Small-scale agriculture

Small-scale agriculture is crucial for communities around YNP, but land conversion is minimal. Infrastructure development, however, enables settler expansion, posing a significant threat to the park's forests, particularly through colonization and agriculture, as identified by the YNP administration.

d) Invasive species

The introduction of non-native species can have negative effects on the park's ecosystems (Arellano, 2023; Lham et al., 2019; Suárez et al., 2012). A number of 12 respondents mentioned invasive species as a direct driver for forest ecosystem changes. Generally, they are connecting invasive species with the monocultures and colonists' activity.

e) Mining - Gold mining and environmental contamination

YNP, faces challenges from illegal gold mining, leading to forest destruction, soil and water contamination, and community displacement (Cisneros-Vidales and Barriga, 2018). According to interviewees, efforts to combat this issue include government initiatives to curb illegal mining and enhance Yasuní's protection and surveillance, aiming to preserve its ecosystem and indigenous communities.

f) Hunting and poaching

The Kichwa community expresses concern over poaching and illegal hunting in YNP, highlighting its detrimental impact on larger, emblematic species and noting an increase in tourist inquiries about hunting opportunities. They attribute a rise in hunting and poaching activities to the influx of colonists, indicating growing threats to the park's wildlife.

g) Illegal logging

Illegal logging is not seen as a major challenge by the YNP administration due to difficult transportation conditions. Wood extraction mainly occurs with infrastructure development and colonist activities, without a formal concession system. Only a small fraction of respondents view illegal logging as a significant disturbance to the forest ecosystem.

h) Climate change:

Climate change impacts YNP through rising temperatures and altered rainfall, affecting ecosystems and species (Buytaert et al., 2010). However, local concern is minimal, with few community members recognizing changes in rainfall as a climate change indicator.

iii) Description of indirect drivers for ecosystem change

a) Land governance and promotion of extractive activities by the state

Historically, Ecuadorian governments denied the existence of indigenous peoples living in isolation in Yasuní (Arellano, 2023), promoting oil activities and infrastructure development that led to illegal logging and violent clashes, notably between loggers allied with Waorani and the isolated Tagaeri and Taromenane groups (McCracken and Forstner, 2014), resulting in massacres (Paz Cardona, 2022). International advocacy led to the creation of an "untouchable zone" to protect these groups, but pressures from oil, logging, and settlers persist (Montaño, 2020). The National Policy for Isolated Peoples, established in 2007 (Cisneros-Vidales and Barriga, 2018), and the Yasuní-ITT project, aimed at preventing oil extraction in critical habitats, represent efforts to address these challenges, yet the effectiveness and comprehensive protection of isolated groups remain areas of concern (e.g., the Armadillo block; McCracken and Forstner, 2014).

Research indicates that while most Kichwa community members seek to avoid dependency on oil companies, the Indillama community views them as opportunities (Loaiza et al., 2015). This contrasts with previous studies suggesting a broader acceptance of oil jobs. Many Kichwas fear over-reliance on the oil sector and prefer forest-based livelihoods. They have notably diversified their income through tourism, showcasing a move towards reducing oil dependency (Suárez et al., 2012).

b) Poverty and lack of income sources

Communities around YNP face income challenges due to isolation (Lu, 2001), limited market access, and negative impacts from settlers and resource extraction, like oil, which displaces communities and alters traditional practices. Initiatives to promote sustainable development, such as training in sustainable agriculture, ecotourism, and handicrafts, aim to improve livelihoods and self-sufficiency. Many community members associate economic opportunities with oil extraction and tourism but view oil-related jobs skeptically, seeing them as diminishing independence (Antolín-López et al., 2022). Tourism is valued as a significant opportunity, though it suffered during the COVID-19 pandemic.

c) Presence of colonists in the park areas of influence

Experts highlight that colonists in YNP cause numerous issues (McCracken and Forstner, 2014; Suárez et al., 2012), including deforestation, soil degradation, water contamination, and threats to biodiversity through the introduction of invasive species, hunting, fishing, illegal logging, and the use of weapons (Arellano, 2023; Bass et al., 2010; Etchart, 2022; Finer et al., 2009; Ghanem and Voigt, 2014). These activities lead to habitat loss, ecosystem fragmentation, pollution, and social tensions with indigenous communities. The government's efforts in control, surveillance, and education to protect wildlife face challenges (Espinosa, 2013), due to inadequate law enforcement and the need for sustainable alternatives for communities reliant on natural resources (Cordero and Koeppen, 2021; Etchart, 2022; Wei et al., 2018). The presence of weapons exacerbates violence, ecological disturbances, and risks to park staff (Cordero and Koeppen, 2021; Pływaczewski et al., 2021). The expansion of settler activities, despite community efforts towards sustainable forest management and ecotourism, further threatens the park by encouraging oil extraction and unsustainable agriculture, damaging community initiatives.

Communities near YNP are concerned about colonists claiming land for agriculture, impacting the forest. Kichwa communities practice sustainable agriculture, allowing forest recovery, contrasting with intensive colonization practices. YNP's management identifies colonization as a key problem, hindered by weak regulation and law enforcement.

d) Health and presence of new diseases

Health challenges in YNP are influenced by factors like settler presence, resource extraction, and indigenous community isolation, limiting access to health services due to scarce infrastructure and professional personnel (Henriquez-Trujillo et al., 2021; Weckmüller et al., 2019). Often, communities rely on oil company medical centers for free healthcare (Henriquez-Trujillo et al., 2021; Weckmüller et al., 2019). Settler influx increases disease spread risks, with interactions among settlers, workers, and wildlife potentially introducing new diseases (Henriquez-Trujillo et al., 2021; Loaiza et al., 2015). Efforts to enhance healthcare access and disease prevention are in progress. Despite trust in traditional medicine, communities fear diseases introduced by colonists, highlighting the complex health landscape in YNP.

e) Access to education

Education in YNP poses significant challenges for indigenous communities due to isolation and lack of access to basic services, including education (Kolahi et al., 2013). These communities encounter linguistic, cultural, and economic barriers, compounded by insufficient infrastructure and resources like bilingual teachers and materials (Loaiza et al., 2015). While public school access exists (Suárez et al., 2012), efforts by NGOs and indigenous organizations aim to enhance education through literacy classes, cultural workshops, and environmental education, aiming to preserve indigenous cultural heritage and knowledge. Community members express a desire for improved education, particularly in skills relevant to tourism, such as foreign language proficiency.

f) Loss of cultural identity

The expansion of extractive activities in YNP has led to violent confrontations between indigenous communities and company workers, with communities increasingly depicted as victims of acculturation and violence in self-defense (Espinosa, 2013). Anthropological studies suggest that post-"pacification," indigenous groups like the Waorani shifted from subsistence to commercial activities, gaining income through oil industry employment, tourism, and sales of handicrafts and wood (Lu, 2001). This transition has introduced problems like alcoholism and significant cultural shock and stress, threatening the loss of cultural identity due to settler presence and resource extraction (Kimerling, 2006). Indigenous ways of life, deeply rooted in the land and its resources (Pływaczewski et al., 2021; Rampheri et al., 2022), face disruption, leading to diminished cultural identity, traditional knowledge, and practices (McCracken and Forstner, 2014; Muñoz, 2017; Suárez et al., 2012). Additionally, these changes exert pressure on natural resources and contribute to biodiversity loss and ecosystem degradation, impacting traditional subsistence activities like hunting and fishing (Antolín-López et al., 2022; Lee and Abdullah, 2019).

Respondents worry about losing cultural identity, noting a decline in traditional forest practices and spiritual connections. Many of the respondents indicated this issue as evolution in a negative sense quite a fact in the last period.

g) Low levels of resources for control and monitoring of YNP

Budget cuts and staffing reductions have raised concerns about the adequacy of control and surveillance resources in YNP (Montaño, 2020). With Ecuador facing budget constraints, the ME terminated 398 employees, including 30 from national parks, worsening fears for conservation efforts (Montaño, 2020). YNP, once staffed by 60, now operates with 48 employees, a number insufficient for its vast and ecologically significant area (Taylor et al., 2022). This reduction in resources risks exacerbating illegal activities like deforestation and poaching, threatening both biodiversity and indigenous livelihoods (Leverington et al., 2010). It highlights the urgent need for prioritized funding and collaboration with international and local entities to protect YNP's critical natural and cultural heritage.

According to the results of the interviews, The Kichwa community is well-informed about the YNP administration's activities, acknowledging increased efforts in monitoring and tourism promotion. However, they desire greater involvement and resource allocation from the YNP administration to better support their community.

CHAPTER 5. CONCLUSIONS

- Ecuador initiated biodiversity conservation efforts in 1893, leading to the development of legislation, frameworks, and strategies that consolidated protected area management across the country.
- About 68% of areas identified as critical for conservation, including key species and ecosystems, are located outside of Ecuador's PAs.
- In YNP, 62 ES directly benefiting local communities have been identified and categorized into 14 groups by experts, with food, timber, tourism, and water being the primary ones.
- The METT methodology shows that YNP´s management effectiveness aligns with other national parks. High scores were given for legal status, regulations, context, design approach, objectives, and planning. Lower scores were noted for human talent, financial, and material resources.
- For YNP, improved coordination, clear role delineation, and objective setting are needed among stakeholders due to their significant but disjointed influence on park management.
- For sustainable development in Yasuní National Park, it's crucial to explore new economic models and markets that cater to the area's unique features, such as leveraging its role as a carbon sink and a provider of environmental goods and services.

5.1. Challenges and opportunities

YNP, located in Ecuador's Amazon rainforest, faces several challenges and opportunities.

Challenges: YNP faces critical challenges, including illegal mining and oil extraction damaging the environment and displacing communities, widespread deforestation from logging, agriculture, and infrastructure development, climate change effects altering ecosystems, community struggles due to inadequate access to basic services, and management issues from high personnel turnover affecting effective planning and alignment with sustainable development goals.

Opportunities: YNP, one of the most biodiverse areas globally, stands at the forefront of biodiversity conservation and climate change mitigation, offering a blueprint for sustainable development and ecotourism. By conserving its forests and promoting sustainable practices, Yasuní, can mitigate climate change impacts and support local community well-being. Despite facing challenges like illegal mining, deforestation, and lack of services, Yasuní's conservation and sustainable use are crucial. Collaborative efforts from the government, NGOs, and communities are essential for Yasuní's long-term preservation and leveraging its potential for sustainable development and ecotourism.

CHAPTER 6. ORIGINAL CONTRIBUTIONS, RESULTS DISSEMINATION AND FUTURE RESEARCH DIRECTIONS

6.1. Original contributions

In Ecuador, there are few studies on planning, management, and governance in PAs; there is also a need to evaluate the main risks, threats, tensions on conservation targets, and the relationship with ecosystem goods and services.

The main contributions of this work are:

- Analysis of Ecuador's PA system history, and institutional and legal frameworks to understand management progress and regulations.
- Evaluation of research on PA management, biodiversity, stakeholders, and carbon storage in YNP and the Amazon Region.
- Identification of key stakeholders affecting YNP management across various sectors, assessing their impact on decisions.
- Examination of YNP's productive activities and land use, focusing on community impacts and socio-ecological interactions.
- Assessment of YNP's management effectiveness using the MEET methodology, comparing it with other national parks.
- Identification of socio-ecological attributes in YNP, including biodiversity, indigenous communities, and land use practices.
- Documentation of forest ecosystem benefits as identified by Kichwa communities, highlighting food, health, and cultural values.
- Determination of direct and indirect factors impacting YNP's socio-ecological systems, with emphasis on oil exploitation, infrastructure, agriculture, and socio-economic challenges.

6.2. Future research directions

The present research is aimed at planning management and sustainable development systematically and strategically, inside and outside PAs, in this case, YNP. This study could be the starting point for future research, such as:

- Identifying the main factors affecting ecosystem change in YNP enables the development of risk-resilient management plans for sustainable development.
- Recognizing forest ecosystem benefits allows for the evaluation and incorporation of ecosystem services (ES) into decision-making.
- Analyzing YNP's key socio-ecological attributes facilitates the implementation of adaptive biodiversity management practices to enhance resilience to climate change.
- Understanding factors behind threats in YNP is crucial for crafting strategies and policies to bolster positive impacts and mitigate negative effects, ultimately reducing ecosystem vulnerability.

6.3. Results dissemination

Results produced within the frame of the PhD thesis:

1. Negru, C., **Domínguez-Gaibor, I.,** Hălălișan, A.-F., Popa, B., 2020. Management Effectiveness Assessment for Ecuador's National Parks. Diversity, 12(12), 487. https://doi.org/10.3390/d12120487 (coresponding author)
2. **Domínguez, N.I.,** Coman, C., Popa, B., 2022. Risk assessment and stakeholders mapping: on the way towards adaptive management for Yasuní National Park. Bulletin of the Transilvania University of Brașov, Series II, Vol. 15(64), No.2. https://doi.org/10.31926/but.fwiafe.2022.15.64.2.1.
3. **Domínguez-Gaibor, I.,** Talpă, N., Bularca, M.-C., Coman, C., Popa, B., 2023. Socioecological dynamics and forest dependent communities' wellbeing: the case of Yasuní National Park, Ecuador. Land, 12(2141). https://doi.org/10.3390/land12122141.

Results produced by participation in research teams external to the PhD thesis scope:

1. Mestanza, C., Figueroa Saavedra, H., **Domínguez Gaibor, I.**, Abarca Zaquinaula, M., Lara Váscones, R., Malla Pacheco, O., 2018. Conflict and impacts generated by the filming of Discovery Channel's reality series "Naked and Afraid" in the Amazon: A Special case in the Cuyabeno Wildlife Reserve, Ecuador. Sustainability, 11(1), 50. https://doi.org/10.3390/su11010050.
2. Vásconez, R.S.L., Pacheco, A.O.D.M., **Domínguez-Gaibor, I.,** Saavedra, H.F.F., Mendoza, A.C.H., Valle, L.A.G., 2019. Diseño De Un Sendero Turistico Interpretativo Para La Comuna Kichwa Mandari Panga, Amazonia Ecuador. European Scientific Journal, ESJ, 15(14), 193. https://doi.org/10.19044/esj.2019.v15n14p193.
3. Cuenca, J., Gallardo, K., **Domínguez, I.**, 2021. Percepción social de la calidad y servicio de agua potable en la ciudad de El Coca, Orellana–Ecuador. Green World Journal, 4(1), 001. https://doi.org/10.53313/gwj41-001.
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6. Flores Andrade, B., Verdezoto Carvajal, M., Simbaña Punina, J., **Domínguez-Gaibor, I.,** 2022. Posibles efectos del Cambio Climático en los anfibios de la Amazonía Ecuatoriana. Green World Journal, 5(1), 006. https://doi.org/10.53313/gwj51006.
7. Mestanza-Ramón, C., Mora-Silva, D., D'Orio, G., Tapia-Segarra, E., **Domínguez-Gaibor, I.,** Esparza Parra, J.F., Chávez Velásquez, C.R., Straface, S., 2022. Artisanal and Small-Scale Gold Mining (ASGM): Management and Socioenvironmental Impacts in the Northern Amazon of Ecuador. Sustainability, 14(11), 6854. https://doi.org/10.3390/su14116854.

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