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Overview of Spatial and Economic Valuation for Ensuring Sustainability and Conservation: A Study of Masoala National Park

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Abstract: Masoala National Park encompasses 240,000 hectares within an extensive reserve of biodiversity and fertile soil. Unfortunately, this invaluable resource has emerged as a primary threat to the park's survival due to escalating human pressure. Masoala contends with challenges stemming from agricultural and illegal exploitation. This paper adopts a comprehensive approach by integrating economic valuation and spatial analysis, presenting a dashboard for decision-makers to guide conservation efforts. This approach offers a holistic perspective on the conservation keys. Firstly, the analysis delves into the economic valuation of the park, encompassing both direct and indirect uses. Secondly, utilizing spatial data, the study identifies zones outside the park suitable for alternative income-generating activities. Ultimately, this research furnishes decision-makers with a valuable tool to advance conservation initiatives within Masoala National Park.

Keywords: Masoala National Park, Biodiversity, Human Pressure, Economic Valuation, Spatial Analysis.

1. INTRODUCTION

Masoala National Park is one of the largest parks in Madagascar, covering 240,000 hectares of diverse habitats, including a wet forest (Llopis, Borgerson, & Andrianarimisa, 2022). The climate in Masoala is generally mild throughout the year, with temperatures around 23°C and limited rainfall from January to September. However, it becomes less favorable from October to November and more challenging from January to December. Located in the east of the island, Masoala's activities are highly dependent on its climate. Masoala harbors a significant amount of biodiversity, with ten lemur species, including endemics like Microcebus rufus, Eulemur fulvus albifrons, and Avahi laniger (Rakotondrasoa, 2007). These lemurs play a crucial role in maintaining the ecological stability of the forest by facilitating seed dispersal.

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Additionally, the park is home to 44 amphibian species, 23 fish species, and 143 butterfly species (Rakotondrasoa, 2007). Regarding vegetation, Masoala forest belongs to the Myristicaceae family, with coastal forests characterized by their smaller height and different floristic compositions compared to inland forests (Outlook, 2020). Demographically, Masoala is home to 145,000 people who primarily rely on the primary sector for subsistence. Agriculture remains the mainstay of household subsistence, with the remaining forest considered a reserve for future agricultural expansion (Llopis, Borgerson, & Andrianarimisa, 2022). However, Masoala faces multiple threats to its survival, with human pressure being the most significant. The park has experienced a high population growth rate, resulting in increased human impact (Llopis, Borgerson, & Andrianarimisa, 2022). Food security is a pressing issue, with over 95% of the population living below the global poverty line and facing child malnutrition (Borgerson, Razafindrapaoly, Rajaona, Rasolofoniaina, & D.Golden, 2019). Construction needs and the transportation of furniture contribute to deforestation, endangering many forestry species (Outlook, 2020). Recent research on Masoala has primarily focused on food insecurity and its potential impact on forest and biodiversity (Borgerson, Razafindrapaoly, Rajaona, Rasolofoniaina, & D.Golden, 2019). The most recent work discussed conservation efforts for protecting the Masoala area by establishing alternative income-generating activities through sustainable forest management (Llopis, Borgerson, & Andrianarimisa, 2022). The present paper aims to address the issue of conservation from an economic valuation and using spatial geographic methods. This does not encompass a deep understanding of biodiversity and its individual elements. The paper analyzes the conservation and supply choice decisions by evaluating the total economic value of the park and assessing the threats from human pressure through a spatial plan. Consequently, this paper serves as a decision-making tool to promote conservation.

2. METHODE

The methodology focuses on two main aspects: identifying threats to Masoala Park using data from Open Street Map, NGO Vahatra, and mapme.biodiversity through QGIS 3.4.15; and analyzing papers by (Dabouineau & Ponsero, 2009), (Outlook, 2020) and (Outlook, 2020) to determine the economic total value of the park.

A. Spatial Geographic Analysis:

Masoala National Park is situated between the districts of Antalaha and Maroantsetra on the east coast of Madagascar, divided into five sites, including two marine and three inland sites.
1) Threats to Masoala Biodiversity: All threats to Masoala are primarily from human pressure, directly impacting ecosystem services and biodiversity (Soarimalala, 2018). Agricultural and cultural practices, including Tavy, are major contributors, as the local population depends on forest products for their livelihoods (Outlook, 2020).
2) Threats from the direct use of the park: Throughout the policy crisis in 2009, Masoala's natural resources were highly threatened. This crisis led to illegal exploitation and abuse, resulting in the destruction of many species' habitats. In the park, particularly, the most valuable tree, rosewood, was present. However, this type of tree faced significant illegal exploitation during that time (Outlook, 2020). Table 1 lists the sites that underwent illegal exploitation. This

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illegal activity has a lasting impact on the long-term viability of animal species (Soarimalala, 2018).

Table1: Sites undergone by the illegal exploitation:

Sites	Sector	Observation across the exploitations
Sarahandrano	East of Masoala: -Rich in watercourses and rivers	- Site affected by exploitation and used to be an issue of evacuation.
Sahabe	East of Masoala: -Existence of rivers	- Site affected by exploitation and used to be an issue of evacuation.
Ambohitsitondroina	West of Masoala: -Existence of watercourses and rivers	-Site not affected by exploitation, but the watercourse is an issue of evacuation.

Source: (Soarimalala, 2018)

Agriculture remains the primary activity for the local population. To maintain crop yields and ensure livelihoods, farmers practice a traditional method known as 'tavy.' Tavy is a cultural practice involving the use of fire in the forest to make the land more fertile(Vicariot, Rakotozafy, & Razafimandimby, 1970). In 2014, Masoala experienced a loss of 50 hectares of its forest due to fires. In December of that year, the site of Andranoanala experienced three separate incidents of fire, unfortunately impacting the last ecosystem forest relic in Masoala. According to estimates, these fires destroyed around 85% of the site, including the area that was restored in 2011(Outlook, 2020).

3) Threats from external activities: Through its landscape and biodiversity, Masoala attracts many tourists every year. However, the wildlife inside the park is at risk of disappearing. For instance, the influx of tourists to the park may lead to the loss of its natural beauty and tranquility, making some animal species uncomfortable (Barnes, Burgess, & David, 1992).

B. Economics Valuation:

The total economic value comprises use and non-use values, providing insight into all values generated by goods and services, including ecological ecosystem services (Brahic & Terreaux, 2009). Due to limited data, we focus on use value from Masoala's recent work.

1) Direct use value: The direct use value comprises services or goods used directly by society. In this context, two supplies from Masoala will be estimated using secondary data to assess the economic value of Masoala. Firstly, the park provides a significant amount of plant medicines directly used by society. According to estimates by (Dabouineau & Ponsero, 2009) the tropical forest of Masoala generates €1,214,900 from plant medicines. Additionally, in terms of soil protection, the value was estimated at €292,000.

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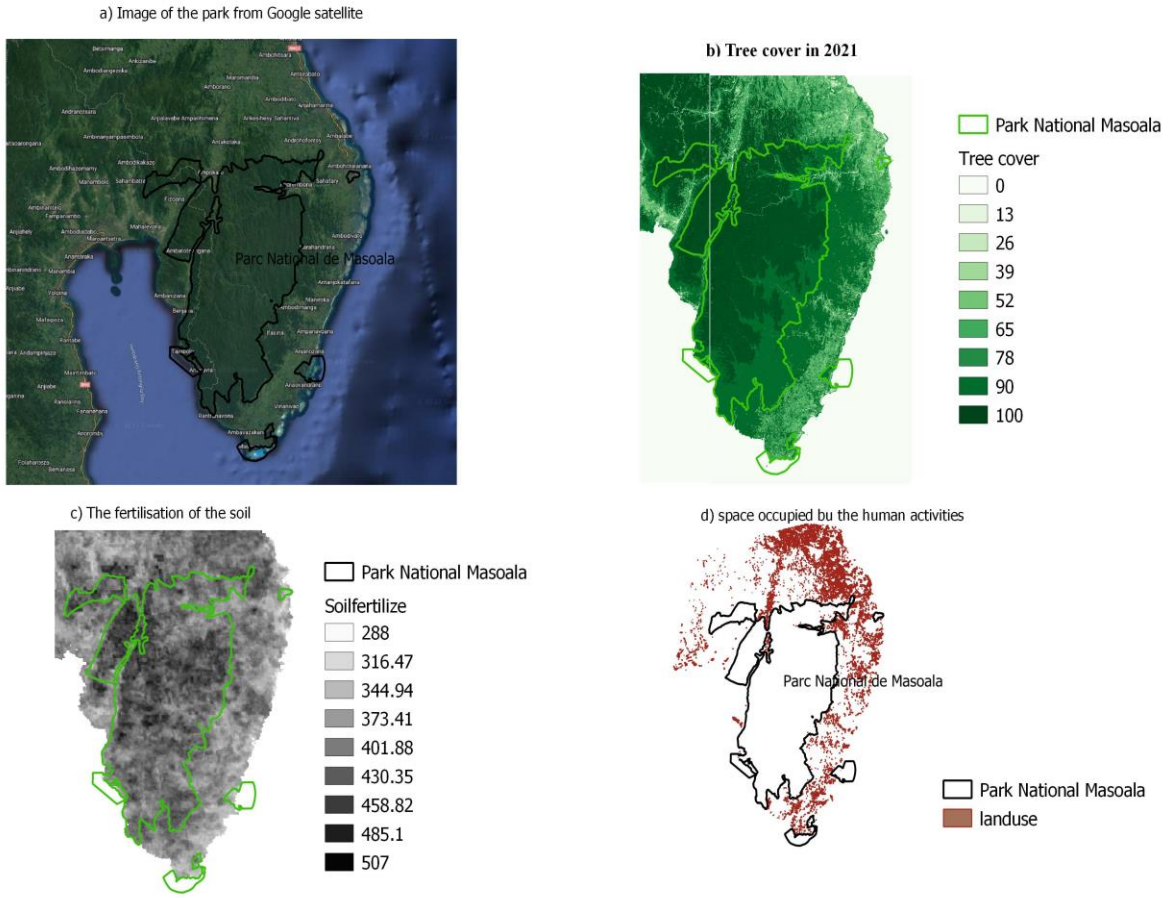

Fig.1. Map showing the tree cover, the fertilization of the soil, and the soil occupied around the park.

2) Inderect use value:

Ecotourism: Ecotourism serves as a tool for economically valuating the ecosystem, with the evaluation focusing on the expenses that a tourist is willing to pay. This includes all costs associated with their visit, such as accommodation, travel expenses, and park fees (Ghermandi, Obura, Knudsen, & Nunes, 2018). assessment relies on the investments made by tourists between Maroantsetra and Antalaha, from which the local community benefits (Ormsby, 2006). Table 2 provides a list of sites for visiting, including all costs that a tourist must pay to admire the biodiversity of Masoala. The estimation of the park's value through ecotourism is based on data from the Madagascar Parc and Masoala Freunde websites. Accommodation costs are not included in this estimation. After combining all the costs paid by one tourist between Maroantsetra and Antalaha and the associated fees, the estimation reaches up to €974.58. However, Masoala receives about 2,000 tourists annually (Ormsby, 2006). resulting in a monetary value of ecotourism around €1,949,160 per year. This value is lower than the

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estimation in 2008 by (Dabouineau & Ponsero, 2009) where they found around €3,973,200 with 3,000 tourists, including accommodation costs.

Table 2: The local cost for visiting Masoala:

Site	**Travel cost for one person €**	**Tour guide €**	**Timing (Minute)**	**Transport services €**	**Fee to enter into the park €**			
					Malagasy visitor		Foreigner visitor	
					Child	Adults	Child	Adults
Nosy Mangave-Maroantsetra	-50	-4.3612	-20 min	-Boat	-0.11	0.44	5.45	9.8
Tampolo-Maroantsetra	-200		-90 min	-Speedboat				
Cap Masoala-Maroantsetra	-650		-180-300 min	-Speedboat				
East cap of Antalaha	-		-4320-5760 min	-Taxibrousse				

(Source: Authors)

Forest services:
Masoala forest holds a prominent position in the carbon market. In 2014, Microsoft and the Zoo de Zurich engaged in discussions about their demand for 140,000 tons of carbon. The last estimation of carbon sequestration in 2008 amounted to €80,935,000(Dabouineau & Ponsero, 2009). According to (Zurich Zoo, s.d.) the carbon sequestration provided by the Masoala forest helps avoid around 33 million tons of greenhouse gas emissions.

Option Value:
The option value refers to the value attached to having the option of using the resource in the future (Torres & Hanley, 2016). Masoala, through its abundance of rosewood, is one of the parks containing numerous rosewood trees in Madagascar. In 2009, one ton of rosewood was sold for €6,000, leading to illegal exploitation. An investigation conducted in 2009 revealed that 1,114 containers were filled with rosewood illegally harvested in the North-east Forest, including Masoala(Ratsimbazafy, Newton, & Ringuet, 2016). The estimation of the option value of these resources is approximately €218 million (Ratsimbazafy, Newton, & Ringuet, 2016).

3. RESULTS AND DISCUSSION

Agriculture and rosewood represent an increasingly important sector that threatens the preservation of the park. This is particularly evident when considering the fertilization of the

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soil within the park. Numerous roads near the park attract people who seek to exploit the park's soil. Population growth has led to an increased need for exploitation to meet household demands, making agriculture the preferred means to ensure subsistence. Consequently, conservation efforts should address this insecurity of subsistence. Economic valuation reveals the worth of services provided by the park. Exploring alternatives for generating income is essential, such as innovating agriculture outside the park using new techniques, expanding fisheries activities for households near the ocean, and establishing an apiculture site, especially in areas with sufficient water.

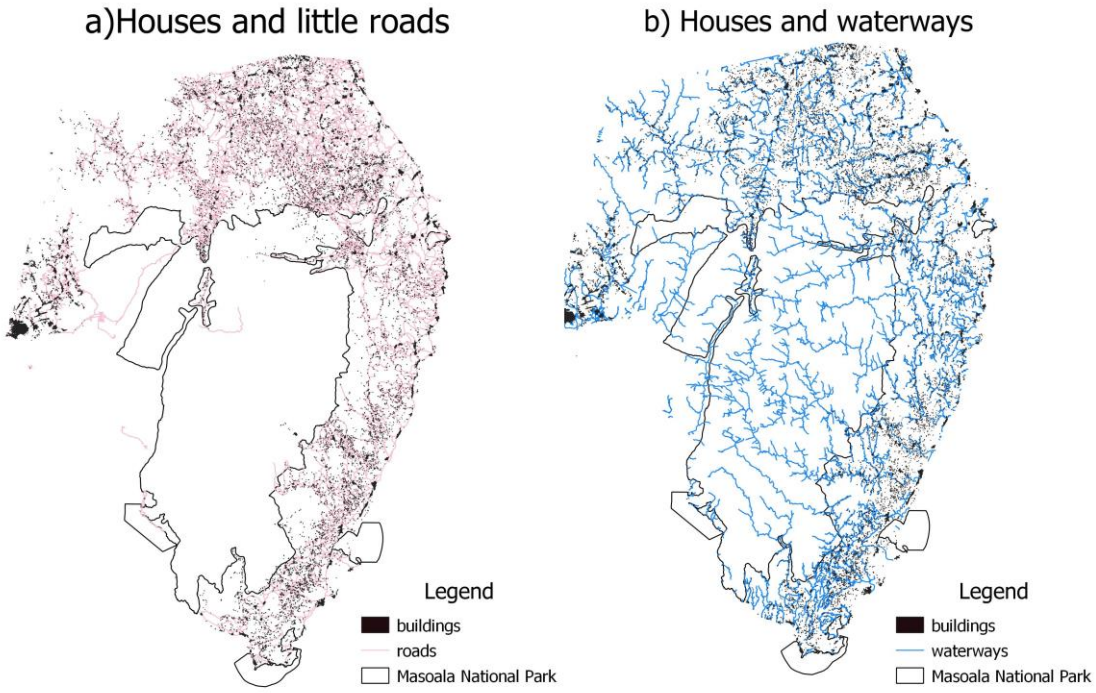

Fig.2. Map showing the tree cover, the fertilization of the soil, and the soil occupied around the park.

The effective management of the park yields an estimated value of approximately €300,441,900. The option value constitutes a significant portion of this amount, totaling €218,000,000, surpassing the combined direct use value of approximately €1,506,900. The forest service contributes around €80,935,000 to this valuation. The significance of indirect use value, as illustrated in Fig. 4, surpasses that of direct use value in terms of monetary value. This underscores the need for a comprehensive economic valuation to guide conservation efforts effectively. Effectively allocating this value within the market is essential for evaluating ecosystem payment services. In this context, an exercise of particular interest for decision-makers is to leverage this value to support sectors contributing to conservation and preservation financially. For instance, prioritizing tourism activities and investing in road infrastructure that allows visits to the park while respecting its tranquility can be beneficial. The results from the

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Fig.2. can serve as a tool to select priority conservation zones by examining areas close to villages.

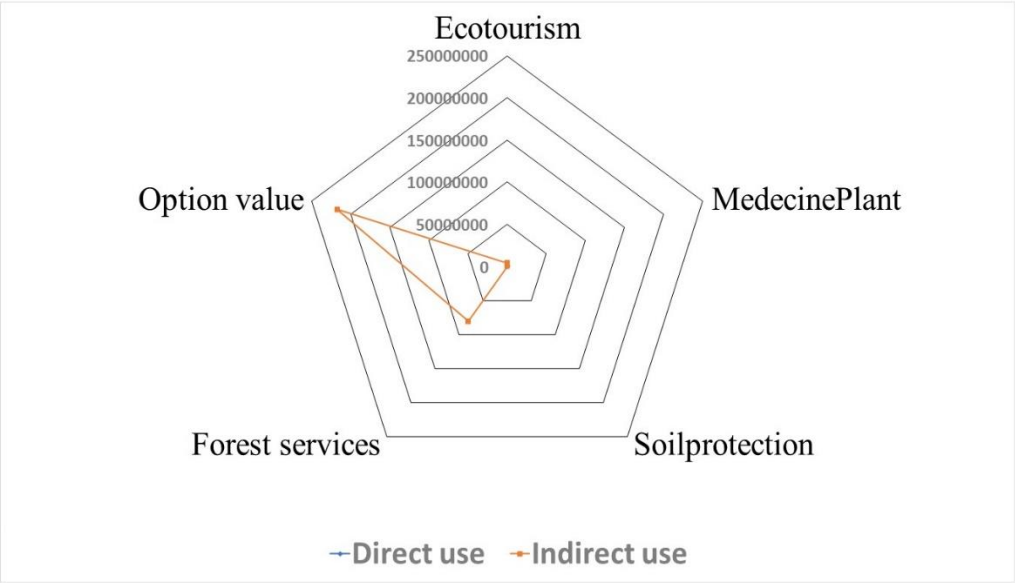

Fig.3. Spider charts of the combination of the direct use and indirect use value.

The Masoala National Park boasts natural resources that have not been fully utilized for its preservation. Paradoxically, these very resources can become threats to conservation. Effectively managing the Masoala National Park requires an analysis of its economic value and the application of spatial geographic methods. The paper aims to comprehensively capture the entire economic value of the park. Identified areas requiring intervention include unoccupied land outside the park. To enhance alternative income-generating activity, the proposal involves implementing ecotourism activities and establishing infrastructure such as roads, hospitals, and hotels. The focus should be on developing this sector, especially during the months of January to September when the park experiences limited rainfall. Interventions and initiatives should be strategically planned during these months to ensure optimal results. Policy stability and good governance can serve as crucial solutions to ensure the stability of the park and prevent illegal exploitation, as exemplified by the events in 2009 when approximately 52,000 tonnes of precious wood were illicitly harvested, including 100,000 rosewood and ebony trees (Ej Atlas, 2023). A robust and consistent policy framework, coupled with effective governance, is essential for deterring and addressing such incidents, thereby safeguarding the park's ecological integrity and resources.

4. CONCLUSION

In conclusion, the paper integrates data from various sources to compare estimates of economic value and incorporates spatial analysis to identify areas not captured by economic evaluations. This combination of economic analysis and spatial assessment provides a comprehensive

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understanding of conservation. The subsequent paper will delve into a matching method to pinpoint specific conservation interventions, thereby presenting optimal policies for effective preservation.

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