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ECONOMIC VALUATION OF ECOSYSTEM GOODS AND SERVICES IN COASTAL VILLAGES ON THE CENTRAL COAST OF LA GUAIRA (VENEZUELA) USING THE NETWORK ANALYSIS PROCESS AS A MANAGEMENT TOOL FOR CONSERVATION

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INTRODUCTION

Coastal ecosystems are one of the most important pillars of environmental sustainability and human well-being. These areas provide essential ecosystem goods and services such as climate regulation, storm protection, erosion control, carbon sequestration, food provision, and support for economic activities linked to tourism and artisanal fishing (Hernández-Blanco et al., 2022; and Contreras del Valle and Starnfeld, 2022). However, growing pressure on these ecosystems in Latin America, resulting from urban expansion, mass tourism, and extractive practices, has led to accelerated degradation that compromises their ability to sustain local communities (Díaz, 2024; La República, 2024; and The Latin American Post, 2024). In this context, Arango et al. (2023) argue that the economic valuation of ecosystem goods and services becomes a strategic tool for highlighting their importance and guiding public policies toward conservation and sustainable use.

In Venezuela, the situation is particularly critical. The state of La Guaira, located on the central coast, is home to a wealth of natural resources, including beaches, mangroves, reefs, and fishing communities that depend directly on marine resources. However, pressure from tourism projects, unregulated fishing, and pollution has weakened the resilience of these ecosystems (Díaz, 2024; La República, 2024). Added to this is the creation of the La Guaira Special Economic Zone, which, while seeking to boost the national economy, has raised concerns about its environmental impacts on fragile areas of high ecological value (El Nacional, 2025). The tension between economic development and environmental conservation is evident and requires a re-

thinking of management mechanisms that integrate ecological, social, and economic dimensions.

International literature has shown that the economic valuation of ecosystem goods and services is key to reducing the invisibility of environmental benefits and costs in decision-making (Contreras del Valle and Starnfeld, 2022, and Arango et al., 2023). In Central American and Caribbean countries, for example, methodologies have been developed to quantify the value of mangroves and coral reefs, highlighting their role in coastal protection and in generating tourism income (Hernández-Blanco et al., 2022; Contreras del Valle and Starnfeld, 2022; and Rincón-Ruiz et al., 2019). These studies have served as the basis for restoration and conservation policies, showing that the integration of economic criteria strengthens the legitimacy of environmental actions. In the case of Venezuela, there are still few studies that apply robust and participatory methodologies to assess coastal ecosystems, which limits the ability of decision-makers to design effective strategies.

The Analytic Network Process (ANP) emerges as an ideal methodology for addressing this problem. Unlike linear models, the ANP allows for the consideration of interdependencies between environmental, social, economic, and political factors, offering a more comprehensive view of complex systems (Giner-Santonja et al., n.d.; Yazo-Cabuya et al., 2024; and Zare et al., 2022). Its application in environmental management studies has proven useful for prioritizing conservation alternatives, assessing risks, and designing participatory policies. In the case of La Guaira, NPM offers the possibility of integrating the per-

ceptions of local actors, scientists, and managers, generating a model that reflects the reality of coastal communities and serves as a management tool for their conservation.

The need to apply this approach is reinforced when considering that coastal communities on the central coast face multiple vulnerabilities: soil erosion, loss of biodiversity, water pollution, and declining fishing productivity (Díaz, 2024). These problems not only affect environmental quality but also the food security and economic opportunities of the population. In this sense, for Arango et al. (2023), placing an economic value on ecosystem goods and services does not imply commodifying nature, but rather recognizing its tangible and intangible contributions to society and ensuring that development decisions incorporate sustainability criteria.

On the central coast of La Guaira state, communities such as Todasana, Osma, La Sabana, Oritapo, and Urama have been the subject of recent studies that highlight both their cultural wealth and the environmental pressures they face. Research on Afro-descendants on the central coast of Venezuela has documented the deep relationship these populations have with the territory and historical memory, underscoring how cultural identity is intertwined with the use of natural resources (Altez, 2016). Likewise, reports such as that by Lares (2024) have highlighted the vulnerability of Todasana to climate change, especially in terms of access to water and food security.

This background reinforces the need for methodologies that integrate environmental, social, and economic dimensions into decision-making. The economic valuation of ecosystem services, applied to these communities, not only makes visible the

tangible contribution of ecosystems to the local economy, but also recognizes their intangible value in terms of identity, legacy, and social cohesion. In this sense, the Analytical Network Process (ANP) is presented as an ideal tool that can guide more inclusive and sustainable conservation policies.

Likewise, economic valuation becomes a bridge between science and politics. By translating environmental benefits into terms that are understandable to decision-makers, it strengthens the capacity to design regulations that promote positive externalities and reduce negative impacts (Gómez et al., n.d.). In the case of Venezuela, where environmental management has been marked by institutional limitations and a lack of resources, tools such as the NPV can contribute to more transparent and participatory governance, in line with the Sustainable Development Goals (SDGs).

Therefore, this research aims to economically assess the ecosystem goods and services of the coastal towns of La Guaira state (Osma, Oritapo, Todasana, Urama, and La Sabana) using the Network Analysis Process (ANP), in order to generate inputs that guide conservation and sustainable management policies. This work seeks to fill a gap in the national literature by providing a comprehensive methodology that highlights the strategic importance of coastal ecosystems and promotes their defense as natural and social heritage. The introduction of economic criteria into environmental management is not intended to replace the ethical and cultural dimension of conservation, but rather to complement it, offering solid arguments to guarantee the well-being of communities and the resilience of ecosystems in the face of global challenges.

METHOD

The research was conducted using a mixed (qualitative and quantitative) approach, due to the nature of the measurement and data processing, and because it involved a series of highly complex interrelationships between social actors from different towns (despite sharing the same ecosystem), all with different views on the proper use and management of natural resources. The dialectical method was used because, through dialogue, ideas and perceptions were contrasted, and a better understanding of the reality of what was happening was achieved.

Although observations were made in situ in the study area, the research was non-experimental because there was no manipulation of variables. However, most of the information required was obtained through bibliographic research and interviews with management actors, who were identified only by their area of expertise in order to protect the confidentiality of sensitive data on the situation in the coastal zone.

The research was also longitudinal, as the calculated economic value is valid only for the time frame in which the study was conducted; however, this value may change in the future due to fluctuations in the ecological or socioeconomic conditions of the protected area.

The following premises were considered for the development of the study:

1. Territorial scope: The study focused on the coastal communities of Osma, Oritapo, Todasana, Urama, and La Sabana, all located on the central coast of La Guaira state. This geographical strip, popularly known as “the coast,” is an area of high ecological and so-

ciocultural relevance, where tourism, fishing, and community dynamics converge.

2. Ecosystem homogeneity: Given that the five towns share similar environmental characteristics—marine-coastal ecosystems with regulatory and service provision functions—it was decided to construct a common Total Economic Value (TEV) scheme. Differences between localities were addressed only through the specific valuation of each ecosystem good or service, which made it possible to identify nuances without losing sight of the overall picture of the system.

3. Comprehensive management plan: In response to a request from the competent authorities in the area, a unified environmental management plan was developed for the entire marine-coastal ecosystem under consideration. This plan seeks to coordinate conservation, sustainable use, and community participation actions, avoiding fragmentation of efforts and promoting a coherent management strategy.

4. Sample selection: For the different phases of the methodology, non-probabilistic convenience sampling was used (Otzen and Manterola, 2017). The sample consisted of actors with direct or indirect links to the communities studied: permanent residents, frequent visitors, institutional managers, and specialists with technical knowledge of the environmental dynamics of the area.

5. Legality criteria: The VET was constructed exclusively on the basis of ecosystem services associated with ac-

tivities permitted under the current legal framework. Illegal or unregulated practices were thus excluded, ensuring that the valuation reflected only legitimate and sustainable uses.

6. Reference currency: The US dollar (USD) was used as the reference currency for calculating economic values. This decision was made in response to the volatility of the Venezuelan exchange rate system and the need for a stable unit that would allow for more reliable comparisons and analyses over time.

The methodological process followed in this research was designed to ensure technical rigor while reflecting the reality experienced by the coastal communities of La Guaira state. The following details the treatment and procedure for data management:

1. Systematic review of existing knowledge:

A survey of the specialized literature was conducted, which allowed us to build a theoretical basis for the economic valuation of ecosystem services. This review not only provided conceptual background, but also helped to identify gaps in information and methodological approaches applicable to the Venezuelan context.

2. Preliminary identification of ecosystem services:

Based on the theoretical review, an initial list of thirty (30) ecosystem services present in the five (5) coastal towns was drawn up. Each service was associated with a type of economic value. To validate this list, participant observation was used, through two field visits that allowed the theory to be

contrasted with the perception of local actors. Subsequently, the *Protected Area Benefits Assessment Tool* (PA-BAT) by Ivanić et al. (2020) was applied, which enriched the inventory and allowed for the recognition of a total of thirty-eight (38) ecosystem services.

3. Construction of the ANP multi-criteria model:

Once the Total Economic Value (TEV) scheme had been defined, a decision model based on the Analytic Network Process (ANP) was designed. To this end, a matrix of binary correlations (0 and 1) was developed, which made it possible to identify dependencies and influences between the different criteria. Given the complexity of the model, services with low incidence (less than five points of influence) were filtered out, leaving a final total of twenty-eight (28) relevant ecosystem services.

4. Grouping into value clusters:

The selected services were organized into five (5) categories: Direct Use Value (DUV), Indirect Use Value (IUV), Option Value (OV), Legacy Value (LV), and Existence Value (EV). This classification facilitated the modeling of interdependencies, reflecting how values relate to each other and how they influence the overall perception of the ecosystem.

5. Paired comparisons with management actors:

To rank the services, the paired comparison technique was applied between criteria and clusters. Eight key actors

participated: institutional representatives (INPARQUES and the Governor's Office), NGO members, academics, local residents, and frequent users of the area. *Super Decisions*® software, developed by Thomas Saaty (2001), was used, which allowed the ANP to be applied in a practical and understandable way. Each participant was given a questionnaire accompanied by clear definitions of the services, which ensured a consistent interpretation.

6. Aggregation of judgments and consistency of results:

The responses obtained were integrated using the geometric mean, which allowed individual preferences to be consolidated into an overall result. This procedure ensured greater consistency in the ranking of services, following the methodological recommendations of Acuña (2015) and Saaty (2001).

7. Determination of the anchor or pivot value:

The analysis revealed that the criterion with the highest weighting corresponded to a Direct Use Value (DUV). This result was expected, given the problems reported mainly by the inhabitants of the different areas. For its valuation, the substitution or replacement method was applied, using market prices, which allowed for both the physical and economic quantification of this service.

8. Calculation of the Total Economic Value (TEV)

Based on the anchor or pivot value, economic quantifications of the remaining ecosystem services were estimated. The sum of these values formed the TEV,

which is presented as a communication and management tool. This result provides a common language between technicians, authorities, and communities, highlighting the economic benefits that are often underestimated in decision-making regarding the towns on the central coast of La Guaira state.

RESULTS AND DISCUSSION

- After applying the different methodologies, the results obtained reflect the uniformity of the assessment of the area as a single ecosystem. This statement is described below as part of the findings:
- In relation to the systematic review, it was found that there are some studies referring to coastal towns that reveal sustainability problems such as the deterioration of water collection systems and dependence on agriculture, making communities highly vulnerable to sea level rise and climate variability. Furthermore, they reflect the marginalization in terms of development and conservation policies to which they have been relegated. However, very few studies were found to understand the dynamics of the area and management needs.
- A review of the legal framework revealed that it is very outdated and does not meet the current needs of the area. These documents are: Decree with Force of Law on Coastal Zones (2001, reprinted 2014), and the Land Use Plan and Regulations (PORU) for the Central Coastal Zone Soil, Forest, and Water Protection Area (2017). The most recent document refers to the La Guaira Special Economic Zone (2023).

- There are previous valuation studies using ANP, but they are not related to the valuation area. The studies relate to Waraira Repano National Park and correspond to Frontado (2019) and Díaz-Martín et al. (2014).
- As a result of the identification of services, a total of thirty-eight (38) ecosystem goods and services provided by the study area (shared by the five villages) were determined, as a result of the theoretical review, participant observation, and the application of the Protected Area Benefits Assessment (PA-BAT) tool, which allowed for the identification of many, sometimes unrecognized, that provide benefits to living beings and whose conservation is vital to the health of ecosystems.
- With the ecosystem services determined, the Total Economic Value (TEV) Scheme was developed at two levels, necessary for the application of the Network Analysis or NAM methodology. The first level considered Use and Non-Use Values, and the second level considered Direct Use, Indirect Use, Option, Legacy, and Existence Values.
- The decision-making model for the Network Analysis Process (ANP) was designed, consisting of five clusters corresponding to the values, and the services became part of the criteria that make up each of the clusters. However, for the final model, it was necessary to reduce the number of services due to the extensive and complicated nature of the model, working with only 28 ecosystem services.
- Once the prioritization questionnaire was designed and applied to the eight actors selected for their relationship with the coastal communities, the most weighted criterion was “Water Supply,” followed by “Water Quality” and “Endangered Species.”
- The highest weighted criterion was not surprising, as it was the biggest problem recognized by the community. Furthermore, it belongs to the “Direct Use Value” cluster, as expected in the methodology in order to work with market prices, applying the substitution or replacement cost method.
- The approach used to construct the matrices was systematic, and the robustness of the tool was verified, as the results did not vary with small variations in the judgments or weights of the criteria.
- The basis for the physical quantification of the water supply flow was obtained comparatively for the five towns studied, as shown in Table 1. For valuation purposes, the estimated supply of 600 L/s was taken (for the five towns), this being a technical data that reflects the projected capacity of the coastal system. The actual supply is much lower and highly irregular, highlighting the gap between planning and effective access.
- The previous point highlighted the lack of research, studies, and/or inventories (measurements) on the actual water supply in coastal towns. According to the communities themselves, the causes of this finding are related to budget deficits and poor planning.

Town/ Community	Estimated supply (official plans)	Actual supply reported	Observations
Todasana	Part of the Maya Picture system (600 L/s projected for the entire strip)	Irregular supply, weeks-long outages; dependence on tanker trucks	High vulnerability due to lack of infrastructure and limited access to drinking water
Osma	Included in the western coastal axis (target: 600 L/s)	Very low actual supply; insufficient local wells	Small community, dependent on artisanal water collection and occasional distribution
La Sabana	Supply planned through rehabilitation of 36" pipes	Frequent interruptions; partial access via cisterns	Tourist area, additional pressure from visitors
Oritapo	Included in the comprehensive water recovery plan	Intermittent supply, heavy reliance on alternative sources	Affected by pumping and distribution failures
Urama	Included in the coastal system (600 L/s overall)	Minimal actual supply; reports of up to one month without water	Community with strong impact on agriculture and fishing

Table 1. Water supply in the towns on the coast of La Guaira

Source: Batatin (2023), El Clarín (2024), and MinAguas (2024)

Table 1. Economic quantification of the ecosystem services provided by the coastal villages

Ecosystem Service	% Final Model	% / 100	Economic Quantification (\$)
Food and Raw Material Production	0.068	6.8068	1,524,001.77
Medicinal Plants	0.043697	4.3697	978,349.67
Ornamental Resources	0.038149	3.814888	854,130.47
Water Supply	0.277846	27.784575	6,220,800.00
Scientific Contributions	0.041141	4.114063	921,113.96
Soil Formation	0.031109	3.110925	696,517.48
Soil Enrichment	0.060378	6.037800	1,351,827.27
Biogeochemical Cycles	0.052639	5.263938	1,178,564.09
Hydrological Cycles	0.004449	0.444913	99,613.25
Species Reproduction	0.048563	4.856288	1,087,293.70
Photosynthesis	0.029803	2.980338	667,279.72
Water regulation	0.011197	1.119725	250,699.72
Air Quality	0.024285	2.428488	543,723.81
Watershed Protection	0.022834	2.283350	511,228.39
Water Quality	0.026546	2.654550	594,337.85
CO ₂ capture	0.006330	0.633000	141,724.91
O ₂ production	0.008284	0.828388	185,471.00
Erosion, translocation, and sedimentation	0.027319	2,731,850	611,644.86
Socio-natural disturbances	0.016820	1.681975	376,584.13
Tourism potential	0.035857	3.585688	802,813.96
Habitat Conservation and Species Refuge	0.012712	1.271225	284,619.67

Biodiversity Protection	0.012113	1.211288	271,200.02
Genetic Resources	0.007381	0.738113	165,258.97
Aesthetic Value and Inspiration	0.055483	5.548275	1,242,225.56
Recreation	0.038050	3.804975	851,911.12
Endangered Species	0.005013	0.501275	112,232.47
Prevention of Irreversible Changes	0.030927	3.092650	692,425.82
Culture	0.053296	5.329625	1,193,271.13

- The estimated supply of 600 L/s is equivalent to 51,840,000 liters of water in 24 hours (1 day of continuous service). This is equivalent, in terms of replacement value, to the purchase of 4,320 to 5,184 tanker trucks per day, depending on the capacity of the vehicle (10,000 to 12,000 L). Now, given that in Caracas and surrounding areas (including La Guaira), prices of between US\$25 and US\$40 per tanker service are reported, especially in remote communities or when demand is high, the highest cost was taken due to the difficulty of access, US\$40 per tanker, which is economically equivalent to US\$207,360/day, representing **US\$6,220,800/month**.
- The replacement cost value obtained for the water supply service provides an idea of the economic value of water in the area when brought to market.
- The result referring to the value of the water supply corresponds to the anchor or pivot value (VUD). Once the anchor value was quantified economically, the rest of the values that make up the Total Economic Value (VET) scheme were calculated, thanks to the weighting that composes them (Table 1), obtaining the following result:

$$VET_{costa} = 24,410,864.79 \text{ USD (\$)}$$

- Although communities recognize water supply as a fundamental ecosystem service, the estimate may be considered low, possibly because the community considers water supply to be a service that should be provided by the state at no cost, and therefore the willingness to pay (WTP) is lower, and this is reflected in the value they give to other services because it is a weighted matrix.
- Although structural interventions in water supply for the towns of La Guaira state are reported, such as the construction of community wells in parishes such as Caruao, as well as the rehabilitation of pipes and storage tanks in order to strengthen local distribution in conjunction with the implementation of community distribution systems, managed in coordination with Hidrocapital and grassroots organizations, no source mentions the amount of investment, nor is the amount allocated to these towns in terms of constitutional funding available, let alone for the preservation of their vital ecosystems. However, it could be said that the conservation of ecosystem services and the services they provide makes a major contribution to the country's national economy, which is not accounted for in GDP and constitutes an important part of our natural capital.

As the **VET** is a benchmark value whose sole purpose is to generate conservation measures, the final phase of this research was a plan whose objective was to establish measures for the sustainable management of the ecosystem services provided by the five villages of La Guaira, with a scope of applicability to all areas of the park and with the participation of all management actors, through monitoring, conservation, use, and evaluation activities.

The management plan designed for the coastal villages included six fundamental aspects to ensure sustainable management:

1. The training of public officials at all levels associated with the management of the study area in issues of sustainability and ecosystem resource management.
2. The implementation of awareness-raising strategies on the use and conservation of ecosystem goods and services.
3. The existence of financing mechanisms to ensure long-term sustainability.
4. The incorporation of appropriate tools for monitoring ecosystem goods and services.
5. The definition of criteria for evaluating their status.
6. The establishment of mechanisms for monitoring and communicating progress.

These actions seek to strengthen the management of ecosystem services and ensure their functionality within the environmental and socio-economic system of the study area. It is worth noting that the design of the Management Plan does not follow any specific methodology or regulations, in order to simplify implementation for all actors involved in the process.

CONCLUSION

Research on the Total Economic Value (TEV) of ecosystem goods and services in the coastal towns of the Central Coast of La Guaira (Osma, Oritapo, Todasana, Urama, and La Sabana), using the Analytic Network Process (ANP), highlights the need to integrate sustainability dimensions into land management.

Specifically, the following three aspects can be concluded:

a. Strategic Visibility Through Economic Valuation

Economic valuation is positioned as a strategic tool that goes beyond mere quantification. Its importance lies in:

1. Combating the invisibility of environmental benefits: It translates tangible and intangible environmental benefits into terms that are understandable to decision-makers. This is crucial in a context where economic development pressures, such as urban expansion and the creation of the La Guaira Special Economic Zone, threaten the resilience of these fragile ecosystems.

2. Strengthening the Legitimacy of Conservation: By assigning a monetary value (such as the *VETcosta of US\$24,410,864.79*) to ecosystem services, it provides a solid argument for justifying investment in conservation.

3. Generating a Common Language: The **VET** serves as a communication tool that creates a shared understanding among technicians, authorities, and communities about benefits that

are often underestimated in decision-making. The fact that water supply was identified as the main problem by the community and the criterion with the highest weighting reflects an alignment between social need and economic value.

b. The Need for a Sustainable and Comprehensive Management Plan

Economic valuation is not an end in itself; its true value is realized when it serves as the basis for the design and implementation of a Comprehensive Management Plan through:

- 1. Coordination of Efforts:** The plan must be unified for the entire marine-coastal ecosystem under consideration, avoiding fragmentation and promoting a coherent management strategy. This is vital given that the five villages (Osma, Oritapo, Todasana, Urama, and La Sabana) share a similar ecosystem and problems, such as high vulnerability to climate variability and marginalization in terms of development policies.
- 2. Holistic Approach:** The plan must address key aspects for long-term sustainability, including:

- ✓ **Monitoring and Evaluation:** Incorporating appropriate tools for monitoring and defining evaluation criteria on the status of ecosystem goods and services.
- ✓ **Financing Mechanisms:** Ensuring sustainability through financing mechanisms.

- ✓ **Transparency:** Establish mechanisms for monitoring and communicating progress.

c. Community Participation and Awareness as Key

Community participation and awareness are essential elements for the legitimacy and success of any conservation plan, especially in areas such as the central coast of Venezuela, where cultural identity is deeply intertwined with the use of natural resources. This requires:

- 1. Integration of Perceptions:** The use of robust and participatory methodologies, such as the ANP, allows for the integration of the perceptions of various key actors (residents, managers, academics, and users), generating a model that reflects the reality of coastal communities and avoids the imposition of external views.
- 2. Need for Awareness and Training:** The management plan must include training for public officials on sustainability issues and the implementation of awareness strategies on the use and conservation of ecosystem goods and services. This is essential to change perceptions and promote a willingness to pay (WTP) that reflects the real value of natural capital, counteracting the idea that services should be provided by the state at no cost.
- 3. Transparent Governance:** Having participatory tools and approaches contributes to more transparent and participatory governance, aligned with the Sustainable Development Goals (SDGs).

In short, the economic valuation of La Guaira's coastal ecosystems is more than just a figure; it is a bridge between science and politics and an indispensable basis for inclusive and sustainable management. By highlighting the economic contribution of natural capital and integrating the voice of communities into a clear management plan, the defense of this natural and social heritage in the face of global challenges is reinforced.

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