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A Participatory Approach to Economic Valuation of Ecosystem Services in Andean Amazonia: Three Country Case Studies for Policy Planning

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Abstract: Ecosystem services have been steadily incorporated into policy and planning, particularly for conservation. While biophysical and economic values are often part of ecosystems assessments, integrating participatory approaches with these valuation tools into planning is essential. This study demonstrates the importance of undertaking case studies with an integrated approach from valuation to practice. We focus on the evaluation of ecosystem services based on user priorities in three different countries that comprise the northwestern part of the Amazon basin: Colombia, Ecuador, and Peru. A total of 473 community and government representatives were interviewed and their priorities for ecosystem services were elicited. We used three approaches to value the prioritized services, market prices, cost avoided, and the value transfer method. We linked the economic valuation results with policy and development alternatives that focus on ES management and we utilized an adaptive policy framework as a crucial step to assess the "trade off" in relation to any given economic, social, and environmental goal. Seven ecosystem services were identified as priorities: fish, timber, and non-timber forest products as provisioning services; disease regulation, water purification, and carbon sequestration as regulating services; and scenic beauty as the only cultural service. The ecosystem services contributing to the highest proportion of local GDP were regulation of malaria (3.9%) in Colombia, followed by ecotourism (1.75%) in Ecuador and fish (1.7%) in Peru. The instruments developed to help integrate this information into policy actions are mostly related to improving the property right systems currently implemented in each country. The results of this study will enable the management of ecosystem service values to be targeted in planning development at the subnational level in each country.

Keywords: land use; environmental policy; land planning; forests; property rights; common resources

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1. Introduction

The Amazon is threatened by unsustainable activities such as illegal logging and mining, as well as land use change for agriculture and cattle raising. This leads to deforestation and water pollution from solid waste, heavy metals, and oil spills. These economic processes have contributed to biodiversity loss, which is further aggravated by the negative effects of climate change, such as fires and droughts, that affect human well-being and the competitiveness of economic activities [1]. The relationship between ecosystem services (ES) and human well-being is increasingly important in development planning, environmental management, and regional policy-making. [2]. There is also a growing interest not only in identifying and assessing ES but also in utilizing economic valuation results and effectively incorporating them into policy and management tools with a view to reverting the reported trend of ES unsustainability and its potential effects on the economic growth and development process [3–6]. ES valuation provides many advantages: (i) from an economic perspective, it gives a quantitative approximation of the value of those ES for which there are no markets or whose markets are imperfect or have failings; (ii) it enables an understanding of possible alternative uses for some biodiversity goods and services, as well as the prospect of confronting future uncertainty with respect to the supply and demand of natural resources [6–11]; and, (iii) from a policy-making point of view, it helps develop arguments to justify (or not) decisions on how to allocate public expenditure on ecosystem conservation or restoration initiatives, on the design and implementation of payment for ecosystem services schemes, on encouraging public participation and support for environmental initiatives, and on comparing the benefits per dollar spent on different projects or programs [12–16].

Despite the existence of a wide range of tools that have been developed with varying advantages, disadvantages, and applicability, the integration of ES into decision-making is relatively recent [2,17,18]. However, ES as a concept is now being mainstreamed into global and regional policies worldwide, from the Convention on Biological Diversity (CBD) (UN, 1992 [19]) to the European Union Biodiversity Strategy [20] or the Regional Biodiversity Strategy (RBS) for the Tropical Andean Countries [21]. A few local case studies have shown the opportunities that exist to address the importance of investing in ecosystem services as a means of promoting poverty reduction, improving productivity and competitiveness, and minimizing the costs of environmental contingences—in sum, to strengthen sustainable development. To this end, some countries are formulating policies and developing instruments to incentivize efficient ecosystem service management. For instance, in several African countries, strategies involving intercropping, pest management, no-tillage cover mulch practices, and drip irrigation have been promoted to prevent soil and water degradation; in every case, there has been an increase in the producer's revenue and/or crop yields [22]. Moreover, regional policy instruments are increasingly taking the ecosystem approach into consideration. For instance, the Environmental Andean Agenda, 2012–2016, recognized the importance of ecosystem services by including as key topics climate change, biodiversity and forests, integrated water resources management, and disaster risk reduction. The instruments for promoting activities in relation to these topics include joint research programs, an Andean environmental information system, capacity building, and funding, among others [23].

The identification and valuation of ES is traditionally based on different types of approaches that are dependent on specific local and national policy goals and is often affected by data availability constraints [24–26]. However, a new and more participatory approach to ES analysis involving users or local communities whose livelihoods are highly dependent on these ecosystems is emerging, with a view to making ES research more relevant to the needs of these end users [24,27,28]. Further, there is a demand for examples that integrate the results of economic valuation exercises in the formulation of public policies and development planning [29,30], as well as corporate strategies [31], under the approach of The Economics of Ecosystems and Biodiversity [16]. ES economic valuation often focuses on provisioning services, while regulating or cultural services are taken into account less frequently [2].

In this study, we seek to use the participatory approach to conduct a user-inspired ES prioritization exercise based on economic valuation methods in order to both integrate into policy-relevant tools and support increased decision-making for sustainable development. Our study focuses on six regions in developing countries, which is a significant contribution, as existing valuation studies have primarily focused on developed countries [32]. Participatory approaches are recognized for contributing significantly to policy-making, improving decision-making quality, and facilitating the integration of ecosystems into regional planning and ES management [33–37]. Reed (2008) emphasizes their value in providing valuable information on complex environmental problems and improving decision-making quality. A participatory process facilitates the integration of ecosystems in regional planning and ES management by improving communication among stakeholders, exchanging perceptions and objectives, and including them in planning goals [33,36,38]. An effective integration of ES in planning based on stakeholder participation requires a framework that considers ecological and social systems. Reed (2008) identifies eight key features of such a framework: (i) a philosophy of empowerment, equity, trust, and learning; (ii) early and continuous stakeholder participation; (iii) representation of relevant stakeholders; (iv) defined and agreed-upon objectives by stakeholders; (v) methods tailored to the decision-making context; (vi) highly skilled facilitation; (vii) integration of local and scientific knowledge; and (viii) institutionalized participation. This approach contributes to designing policy instruments where stakeholders' support facilitates their implementation. Baskent [37] suggests that the framework should also include identification, quantification, valuation, and monitoring of the ES to provide magnitudes on their contribution and motivate stakeholder engagement for conservation.

Historically, participatory approaches have been used to allocate budget resources in local government. [39]. Developing a quantitative assessment to demonstrate citizens' participation in the budget process benefits local financial outcomes. They also show that stronger institutions supporting participation are more equitable and effective without losing efficiency in the budget process. However, there is little analysis on the effectiveness of participation on policy implementation [39,40], as well as on the cost of stakeholder participation [41]. The literature extensively discusses the importance of stakeholder participation in identifying and integrating ES into policymaking. Brody [40], like Reed [35], agrees on the importance of selecting relevant stakeholders to achieve stronger and long-lasting local plans for ecosystem management.

Our participatory approach adheres to UNEP's guidelines [27], which recommend that the regional authority takes the lead and provides support throughout the process. We also adhere to Reed's participatory features. Key stakeholders who are users of ecosystem services participate in prioritizing the ES and selecting policy instruments. A crucial aspect of our participatory process is the collaboration between the regional authority and a specialized technical team to conduct a process to integrate ES into regional development planning. Northwestern Amazonia is a good case study because this area corresponds to different countries that share the same biome but have several socioeconomic, demographic, institutional, and policy differences. The goal of this research is to apply a common participatory approach to ES prioritization and conduct an economic ES valuation as a tool for policy and development planning on the subnational level. To achieve this, we specifically address three research questions: (i) Which ES are considered relevant to local communities (ii); what is the relative importance of the value of a given ES to the economic activity of each region; and (iii) how can economic valuation processes be linked with policy and development alternatives to maintain ES?

2. Methods

2.1. Study Area

The study area covers an expanse of 683,771 km^2 distributed between six subnational regions of Colombia, Ecuador, and Peru, all of which correspond to the Amazon biome and include tributaries of the Amazon River. The subnational regions in question are the departments of Amazonas (109,037 km^2) and Caqueta (90,073 km^2) in Colombia; the provinces of Napo (12,542 km^2) and Sucumbios (18,084 km^2) in Ecuador; and the departments of Loreto (368,852 km^2) and Madre de Dios (85,182 km^2) in Peru (Figure 1). Loreto in Peru accounts for the largest expanse (53.9%) of the study area, followed by Amazonas (15.9%) and Caquetá (13.2%) in Colombia, and Madre de Dios (12.5%) in Peru. Loreto has the largest population (1,039,372 inhabitants) and a human density of 2.82 inhabitants/km^2. Meanwhile, Sucumbíos has the smallest population of the study area (176,742 inhabitants) but the highest population density (9.76 inhabitants/km^2) (Table 1). The main activities in Sucumbios, Napo, Loreto, and Madre de Dios are oil production and mining. Amazonas bases its economy mainly on the extraction of forest resources, fishing, agriculture, and tourism. In Caqueta, the main economic activity is cattle raising.

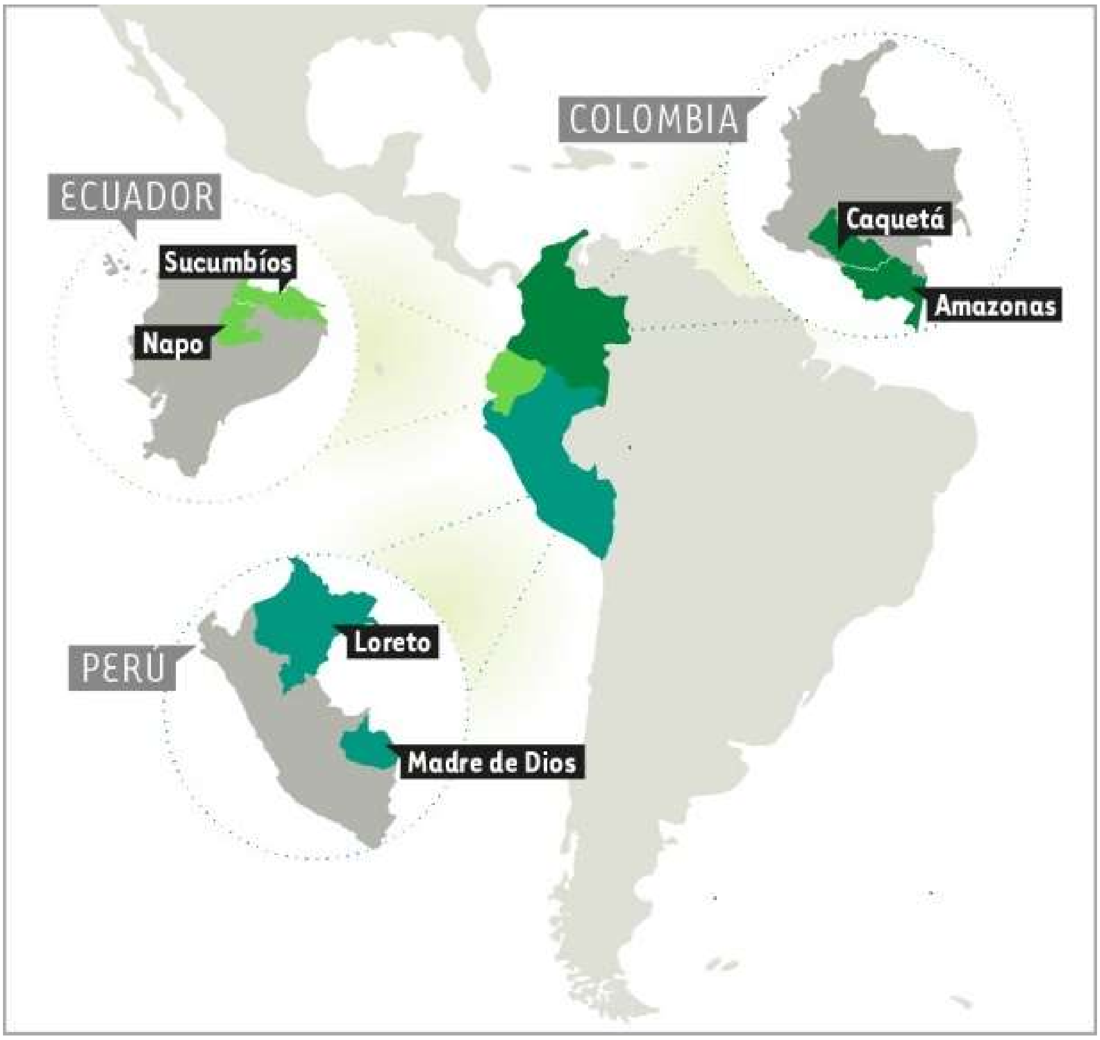

Figure 1. Study Area Map featuring the location of the Amazon subnational study areas in Colombia (Caqueta and Amazonas), Ecuador (Sucumbios and Napo), and Peru (Loreto, Madre de Dios).

Table 1. Population characteristics of the study area by region (2013) and description of stakeholders and local communities attending the workshops.

Country	Region	Population (Inhabitants)	Population Density (Inhabitants/km^2)	Profile of Workshop Participants	Number of People Attending Workshops
Colombia	Amazonas	75,388	0.69	Indigenous, local communities, NGOs, national and local government representatives, producers, NGOs, national and/or local government representatives	80
	Caquetá	471,541	5.30		107
Ecuador	Sucumbíos	176,472	9.76		56
	Napo	103,697	8.27		70
Peru	Loreto	1,018,160	2.76		97
	Madre de Dios	130,876	1.42		63

In Loreto, Madre de Dios, Napo, and Sucumbios, deforestation is primarily caused by land use change for agriculture, oil production, mining activities, and the construction of new roads. These activities are often illegal and lead to the spread of diseases such as malaria, dengue, and diarrhea. Poor fishing practices in Caquetá and Amazonas and illegal mining in Madre de Dios are responsible for river contamination, which affects fish populations and results in mercury contamination. Therefore, human actions have the greatest impact on the ecosystem services of these regions, which are characterized by increasing urbanization and poor sanitation (e.g., Loreto and Madre de Dios) and high poverty rates (e.g., Napo, Sucumbios, and Loreto) [42–44]).

The release of heavy metals is a significant challenge in the Amazon region due to its negative impacts on ES and the well-being of local communities. Heavy metals pollute soil and water, leading to health problems for the local population. The sources of heavy metals are both natural and anthropogenic. A case study conducted in the Peruvian Amazon concluded that heavy metals such as iron (Fe), cobalt (Co), zinc (Zn), nickel (Ni), and chromium (Cr) are associated with natural sources. Anthropogenic activities, such as illegal gold mining, release mercury (Hg), whereas beryllium (Be), lead (Pb), copper (Cu), and manganese (Mn) are released by both natural sources (forest fires and organic matter decomposition) and anthropogenic sources such as areas degraded by solid waste, illegal gold mining, and hydrocarbons. Identifying the sources of heavy metals is essential to establishing regulations that can effectively address the problem [45].

2.2. Data Sources

The ecosystem services identified were valued primarily through market price, avoided cost, and transfer value approaches. Information for each method was mainly collected from secondary sources, supplemented by workshops that involved various stakeholders engaged in economic activities related to ecosystem services. These stakeholders included public officers from regional authorities in the health, environment, and production sectors and academics, researchers, NGOs, entrepreneurs, tourism operators, medical doctors, and producers. The authors developed an ad-hoc working group guide for each workshop (At the beginning of each workshop, a "Capacity Building" part was developed in order to equate basic knowledge among participants on some economics concepts (such as market failures, valuation methods, market and control instruments)), as detailed in Supplementary S4 and S5: Supplementary Information. Furthermore, experts were interviewed using unstructured questions.

2.3. Data Analysis

The participatory approach involves key stakeholders who use or manage ecosystem services (ES) in the prioritization and selection of policy instruments. This approach is based on the Global Environmental Outlook framework [46] and includes capacity building on ES concepts, economics, valuation, and policy instruments. This training was provided prior to the prioritization of ES, presentation of the economic valuation results, and selection of instruments due to varying levels of knowledge among stakeholders. Stakeholders also had the opportunity to share their knowledge on the topics discussed. The regional authority led and supported the process.

The general workflow followed in this study is presented in Figure 2. To ascertain the ecosystems services relevant to local communities alongside local government, we identified actors that were involved at the regional or local level in development planning or in economic, social, cultural, or environmental activities related to ecosystem services management. We then held three workshops in each of the study areas between 27 March 2013 and 19 March 2015—a total of 24 workshops attended by 473 people (Table 1). In addition, we arranged technical meetings with the regional authorities in each region. Ecosystem services were prioritized in the first of the workshops in each region (Figure 2) based on the following criteria: (a) economic importance, i.e., main source of income, job creation, and improved competitiveness for the region; (b) welfare aspects; and (c) availability of information.

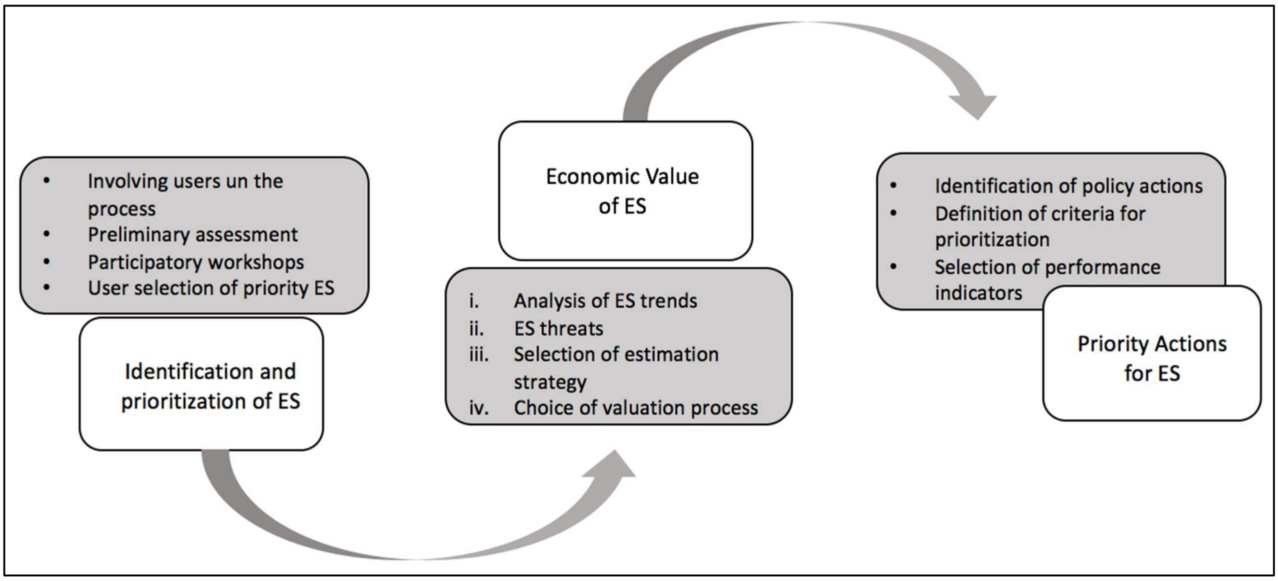

Figure 2. General workflow of the valuation process and policy actions definition (Own elaboration).

Following identification and prioritization of the ecosystem services at each site, we proceeded on to valuation based on the market price, avoided cost, and value transfer methods [47]. International experience in the economic valuation of natural resources and ecosystem services revealed that these methods are usually used when there is limited information access [48]. The first approach employs prevailing prices for goods and services traded in domestic markets [49]. However, in most cases, the markets analyzed are imperfect, so we often resorted to reference prices and costs (from secondary sources such as government agencies, ministries, regional governments, and national statistics institutes and primary sources, through interviews) to estimate a parameter of net income per unit of product sold. The second approach measures the costs incurred by governments, businesses, and/or individuals to reduce or prevent unwanted environmental effects. The fundamental assumption is that economic agents are willing to change their behavior and to make investments to prevent the negative effects of environmental degradation or an increased risk to their welfare [47]. The third approach relies on the transfer of estimated values from other relevant primary studies, i.e., information from existing studies in another similar area, and their subsequent application to this study area [50].

In general, for the economic valuation of the prioritized ecosystem services in each region, we followed these steps (Figure 2): (i) identification of the main characteristics of the economic activity related to the ES under analysis (population, suppliers, and participants in the value chain); (ii) identification of the threats to the ES from socio-cultural, institutional, and environmental perspectives; (iii) selection of an estimation strategy based on the threat(s) identified (in step (ii)) and information limitations; (iv) firstly, using the valuation approaches (price market based, avoided costs, and values transfer), calculation of the ES value based on two scenarios: one in which the local government does not pursue any conservation actions (status quo situation), and another in which the local government does take conservation actions (optimized situation) that deal with the threats identified; and secondly, calculation of the present value of the difference between the ES value under the status quo and optimized scenarios, the result of which is considered to represent an economic loss for society because ES conservation actions are not carried out.

To link the economic valuation results with policy and development alternatives that focus on ES maintenance, we relied on an adaptive policy framework as a crucial step in assessing the “trade off” between any economic, social, and environmental goals (Figure 3).

This is because, within an economy, in a particular place, time, and society, economic agents face elections in both the private and public sector. In this context, incentives, and regulations to promote access to natural resources and adequate environmental quality are key aspects in improving human well-being over time. Moreover, economic valuation of ES provides information to stakeholders on the positive and negative consequences in relation to the use of a given service.

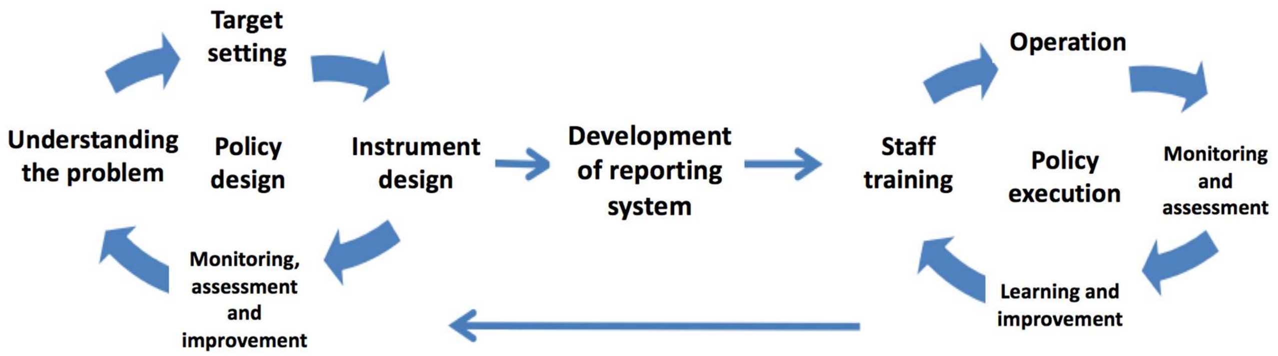

Figure 3. Design and implementation of adaptive policies. Source: Adapted with permission from Swanson et al., 2009 [51], p. 14. Copyright 2009 IISD and IDRC.

To link economic valuation with policy options, we inventoried policy instruments and grouped them into management and regulation, planning and regulation, and market-based instruments [16]. For each group, we recommended a policy instrument selection based on policy goals, costs and benefits, and institutional framework. We prioritized policy actions based on plans, programs, and projects in the region and utilized economic value to identify various ES management and conservation scenarios.

3. Results

We identified fifteen different ecosystem services through the participatory approach. Of these, seven were identified as priorities, some of which were consistent across countries (Table 2). In the case of provisioning services, fish supply was identified as a priority in both Loreto (Peru) and Amazonas (Colombia), whereas timber (roundwood) and non-timber (Brazil nut) forest products were identified in Loreto and Madre de Dios, both in Peru, respectively (Table 2). In the case of regulating services, disease regulation was identified in three sites, Amazonas, Caquetá (CO), and Loreto (PER), while water purification was a priority in Napo and Sucumbios (EC) and carbon sequestration was only prioritized in Caqueta (CO). As to cultural services, scenic beauty was identified as a priority across all sites except for Caqueta (CO).

As to the economic valuation of the prioritized ES, the regulating service of malaria control in the Colombian Amazon represented the highest percentage of local GDP (3.7%) (Table 3), followed by the cultural service of ecotourism in Napo, Ecuador (1.75% of local GDP) and the provisioning service of fish supply in the Peruvian Amazon (1.7% of local GDP). The lowest economic value relative to local GDP also corresponded to fish supply, in the case of Loreto (PER, 0.003%), as well as a water-regulating service in Sucumbios (EC, 0.01%) (This percentage is calculated in consideration of the Gross Added Value of Sucumbios, which includes the oil sector).

Table 2. Initial list of ecosystem services identified and prioritized by study site.

Service Category	ES Identified	Priority ES	Study Site
Provisioning	Food Fish Timber Forest Products Non-Timber Forest Products Water Fibers	Fish	Amazonas (CO) Loreto (PER)
		Forest Products 1. Timber 2. Brazil nut	1. Loreto (PER) 2. Madre de Dios (PER)
Regulating	Diseases Water purification Carbon sequestration Climate regulation	Diseases (malaria)	Amazonas (CO) Caquetá (CO) Loreto (PER)
		Water purification	Napo (EC) Sucumbíos (EC)
		Carbon stock	Caqueta (CO)
Cultural	Scenic beauty Research Spiritual vales	Scenic beauty	Amazonas (CO) Napo (EC) Sucumbios (EC) Loreto (PER) Madre de Dios (PER)

Table 3. Economic valuation of each of the ES prioritized by region, with specific steps in each site.

ES Prioritized	Study Site	Steps			
		(i)	(ii)	(iii)	(iv)
Fish	Amazonas (PER)	Subsistence fishing and commercial fisheries	Unsustainable fishing practices: over-fishing, use of explosives and contaminants	Market-based price. Data: price and catching volumes. Twenty-year (2014–2034) horizon projections. Discount rates: 12% (COL), 9% (PER).	USD 4.3 million/year ≈ 1.7% of local GDP
	Loreto (Iquitos, PER)				USD 0.13 million/year ≈ 0.003% of local GDP
Brazil nuts	Madre de Dios (PER)	Concession holders; medium and large producers living in district capital (Puerto Maldonado), small producers living in production areas (concessions)	Legal and institutional issues: overlapping land property rights	Market-based price. Data: prices, costs, and volumes. Twenty-year (2014–2034) horizon projections. Discount rate: 9%.	USD 0.95 million/year ≈ 0.14% of local GDP
Timber	Loreto (PER)	Extraction, processing, manufacturing, and marketing activities.	institutional weakness: Informal and illegal harvesting activities → degradation of valuable timber species	Market-based price. Data: prices, costs, and volumes. 20 years (2014–2034) horizon projections. Discount rate: 9%.	USD 5.3 million/year ≈ 0.13% local GDP

Table 3. *Cont.*

ES Prioritized	Study Site	Steps			
		(i)	(ii)	(iii)	(iv)
Control of human diseases	Amazonas (COL)	Health of local population	Dengue and malaria (Vivax) vectors due to deforestation	Avoided (medical and treatment) costs and transfer value approaches from Pattanayak et al. (2009) [52] for COL, Fewtrell et al. (2005) [53] and Aguilar et al. (2001) [54] for ECU, and Olson (2010) [55] and Garg (2014) [56] for PER. 20-year (2014–2034) horizon projections. Discount rates: 12% (COL), 9% (PER) and 5.19% (ECU).	USD 0.26 million/year ≈ 0.11% of local GDP
	Caquetá (COL)				USD 0.27 million/year ≈ 0.02% of local GDP
	Loreto (PER)		Malaria (Vivax) vectors due to deforestation		USD 2.93 million/year ≈ 0.07% of local GDP
Water purification, waste treatment	Napo (ECU)		Organic contamination caused by livestock, wastewater, and agricultural activities		USD 0.86 million/year ≈ 0.27% of local GDP
	Sucumbios (ECU)				USD 0.34 million/year ≈ 0.01 % of local GDP
Carbon sequestration and storage, climate change mitigation	Caquetá (COL)	Local population, forests in the region.	Mining, agriculture, and logging activities: change of land use.	Market-based price. Data: carbon stored in natural forests, average value of each type of natural forest (ton/ha). Price: USD 5 per ton of carbon stock. 20-year (2014–2034) horizon projections. Discount rate: 12%	USD 13.9 million/year ≈ 1.2% of local GDP
Recreation and ecotourism	Amazonas	Ecotourism and recreational activities	Illegal mining, oil, and timber exploitation, change of land use, crops, and expansion of the agricultural frontier. Institutional weakness.	Market-based price and value transfer from Victorino et al. (2015) [57] in COL, and the Katelborn et al. (2011) [58] and Newbold et al. (2013) [59] approaches. Data: flow of tourists, prices of accommodations, and tickets and tariffs for reserve and natural areas. Twenty-year (2014–2034) horizon projections. Discount rate: 12% (COL), 5.19% (ECU) and 9% (PER).	USD 1.6 million/year ≈ 0.71% of local GDP
	Napo				USD 5.6 million/year ≈ 1.75% of local GDP
	Sucumbíos				USD 6.8 million/year ≈ 0.28% of local GDP
	Madre de Dios				USD 3.39 million/year ≈ 0.49% of local GDP

Based on the methodology applied, the results reflect the economic loss for society arising from the lack of ecosystem service conservation actions in a 20-year horizon. Thus, for the study site of Amazonas, the loss of the value of ecosystem services in the time horizon considered is in the range of USD 86 million to USD 144 million; while in the case of Iquitos (Loreto), the loss ranges from USD 2.6 million to USD 16.1 million. Expressed as annual averages, the loss for Amazonas is between USD 4.3 million and USD 7.2 million, while for Iquitos it is between USD 130,000 and USD 805,000.

As regards regulating services, the direct and indirect costs of disease (malaria in Amazonas, Caqueta, and Loreto; dengue in Amazonas and Caquetá; and EDA in Napo and Sucumbios) vary between USD 213,400 and USD 520,700 in Amazonas and USD 2.2 million and USD 5.4 million in Caqueta and stands at USD 58.6 million in Loreto, USD 17.2 million in Napo, and USD 6.7 million in Sucumbios.

The main instruments that may help to integrate the results into policy actions (Tables S2 and S3, Supplementary S2 and S3, respectively) are related to improving the property rights system and preventing overlapping property. Other instruments are market-oriented, such as payments for ecosystem services (PES) and certification, and fiscal, such as the works for tax programs and subsidies, among others. For instance, in the case of the provisioning service of Brazil nuts in Madre de Dios, Peru, the lack of property rights has reduced the land area for Brazil nut extraction. As a result, many producers, chiefly families, have endured income reductions. The economic valuation elucidates the scale of this income loss.

4. Discussion

Applying a participatory approach to policy-making can aid in integrating ecosystem services, identifying and prioritizing them, and enhancing their management to improve welfare for local communities and stakeholders and promote sustainable development at the subnational level. Additionally, economic valuation of prioritized ecosystem services can help determine their value and assist in designing instruments to promote sustainable development.

The identification by local communities of fish supply as a priority ES came as no surprise, since this resource is essential for feeding certain population groups (primarily indigenous and coastal). Indeed, fishing activity in the department of Amazonas can be divided into two categories, (i) subsistence fishing and (ii) commercial fishing, while in Loreto, fishing is mainly for subsistence. In Loreto (particularly in Iquitos) and Amazonas (in Leticia, chiefly), per capita fish consumption is 36 kg/year.

As to non-timber forest products, Madre de Dios is the only region in Peru where Brazil nuts are produced, and its market is a major source of income and employment in this region. Since 2000, the production of this good has been carried out in 10,000-hectare concessions granted exclusively for this purpose for a period of 40 years—that is, no other forest concession rights may be granted on these sites [60]. An estimated 864,000 hectares, one-third of the department's forestland, is given over to chestnut stands, which are leased out to a total of 983 dealers in the southeastern region of Madre de Dios. On the other hand, timber production is the economic activity with the highest income and job creation rates; for instance, according to the Ministry of Agriculture (MINAGRI, 2013 [61]), roundwood production in 2012 totaled 662,266 m^3, which represents nearly 27% of Peruvian domestic production. Loreto accounts for 55.16% (9,302,102 hectares) of Peru's total forest production [61], so it came as no surprise that this activity was identified as a priority there.

Regulating services, especially in areas with high incidence of malaria, are a concern for local communities. Deforestation has been linked to the incidence of malaria in other Amazonian regions [55]. In departments highly affected by the disease, the priority ecosystem service is water purification. In both study sites in Ecuador, water purification was identified as a priority ecosystem service. These regions are affected by fecal coliforms due to ranching and poor waste management in villages and towns. Chemical use in livestock production and agriculture (oil palm), oil spills, small-scale gold mining, and extraction of stone materials from riverbeds also contribute to pollution in the area. Additionally, natural events such as constant ash falls from the Reventador and Tungurahua volcanos worsen the situation. Forest carbon stocks were identified in Caquetá (CO) as a priority ecosystem service, and this is probably because Caquetá is the most deforested department in Colombia, accounting for 46% of the total deforestation recorded in the Colombian Amazon [62]. Indeed, between 1990 and 2010, the average annual deforestation was 33,131 hectares, increasing to 37,781 hectares thereafter. In 2013, total Colombian deforestation was 120,993 hectares, of which 57% was recorded in the Amazon region, mainly in the departments of Caquetá-Putumayo, Meta-Guaviare, and San José del Guaviare-Calamar [62]. Meanwhile, in the case of cultural services, scenic beauty is one of those most frequently identified by local communities [63].

In the study area, overlapping property rights pose a common threat to the provision of services. For instance, in Madre de Dios, mining or agricultural rights are assigned in areas that also produce Brazil nuts. As a result, the latter provisioning service is at risk. The values obtained from the valuation exercise, ranging from USD 19.1 million to USD 50.6 million, represent the benefits that the region would lose due to reduced marketable Brazil nut production areas resulting from overlapping rights. On average, this translates to between USD 105,000 and USD 805,000 per year. To conserve Brazil nut production, priority actions include the consolidation of concessions through the update of cadastral information, ecological economic zoning (EEZ), and territorial planning (POT). Additionally, strengthening value chains, product certification, and fair trade initiatives can be achieved through production process, product quality, social responsibility, and eco-labeling certification, as well as transitional subsidies.

Forest degradation in Loreto, reflected in the loss of value of roundwood extracted due to unregulated selective logging, is the main threat to the provisioning service of timber supply. According to the methodology implemented, the economic value of this ES is close to USD 213 million. This can be interpreted as the cumulative loss of value that forests in the region will undergo over the next 40 years (approximately USD 5331.8 thousand per year) if ES conservation actions are not taken. These figures, which point to the benefits of conservation, should be contrasted with the costs of conservation actions. In this case, the proposed priority actions for the conservation of this ecosystem service are: (i) restructuring the land-use property rights of forest spaces or areas by updating the land register; and (ii) defining the uses to which the different areas will be put (agriculture, livestock, oil, and maintenance) and regulating usage according to the activity, taking into account the economic and ecological zoning for the meso and micro levels as well as the land use plan.

As for regulating services, the transfer value approach was complemented by the avoided cost method to value the direct and indirect costs of disease (malaria in Amazonas, Caqueta, and Loreto; dengue in Amazonas and Caquetá; and EDA in Napo and Sucumbios). These can be interpreted as the benefits, respectively, that each region puts at risk by not dealing with the threats facing the ecosystem service. Therefore, the above values can be compared with the costs of implementing certain priority actions for the conservation of the ecosystem, such as a service to encourage forest conservation through voluntary conservation instruments (a payment mechanism for environmental services aimed at local communities as a means of conserving forests and water sources) and the design of a system to monitor changes in vegetation cover and vector development (through an information and early warning system).

In the case of the carbon storage service in Caqueta, this is mainly threatened by deforestation driven by economic activities (mining, cattle raising). The values range from USD 162 million to USD 340 million for a 20-year horizon, equivalent to annual average figures from USD 8.1 million to USD 16.9 million, and can be compared with the costs of suggested priority actions, such as: (i) an incentive to maintain carbon storage through payment schemes for environmental services; and (ii) design and implementation of tools for upgrading urban and rural mapping, through the establishment of a land information system.

With respect to the cultural service to which the economic activities of ecotourism (Amazonas and Madre de Dios) and nature tourism and adventure (in Napo and Sucumbios) are linked, the results show that if deforestation—the main threat generated by different actors promoting illegal mining, oil and timber production, changing land use, illicit crops, and the expansion of the agricultural frontier—continues at current levels, in a horizon of 20 years, a range of magnitudes from USD 2 million to USD 136.9 million (between USD 116,000 and USD 6.8 million annually, approximately) could be interpreted as the value of the lost or damaged ES.

5. Conclusions

Our research aims to demonstrate the usefulness of a participatory approach in conducting an economic-valuation-based, user-inspired prioritization exercise of ecosystem services (ES) to develop policy-relevant tools that support decision-making for sustainable development on a subnational level. The Northwestern Amazonia region is an ideal case study because it is a shared biome with significant socioeconomic, demographic, institutional, and policy differences across countries.

Although the values of ES are not comparable across regions, the interpretation of magnitudes for each region can be useful for local policymakers. For instance, the economic valuation exercise in Amazonas and Loreto for the provisioning service of fish supply aimed to determine the lost value of the resource due to over-extraction (mass trapping), the main threat to this ecosystem service. The calculation of these values is based on secondary data and a regional geographical scope (except for Iquitos), and the use of net income can provide decision-makers with a reference of the orders of magnitude of the benefits at risk due to failure to implement timely conservation actions or sustained ecosystem service management tools. Even though the economic valuation results underestimate ES value—in that they do not consider all the components of the total economic value for each ES—the results are useful because they provide quantitative information that aids an understanding of the contribution of ES to economic activities and human well-being. This equips policy decision-makers with a quantitative element in terms of the profits (direct and/or indirect) of projects under consideration and allows them to compare the costs of implementation, focusing on the most beneficial. For society, decision-making is rendered more legitimate and provides appropriate indications as to how state resources are being used to improve human well-being.

The research results also provide a better understanding of the economics underlying common or open-access resources (e.g., fisheries) and the importance of well-defined property rights and rules that incentivize the conservation of natural resources, given that they satisfy the basic needs of the community. In Amazonas, Colombia, the community recognized the incentives to overexploit a common-property natural resource, such as local fisheries; given the non-exclusive nature of fisheries, these have been subject to steadily increasing effort in terms of fishing activities. As a result, biomass has reduced, increasing the economic cost of access. In addition, the limited supervision by the relevant authorities also exacerbates over-exploitation.

To this extent, certification of and payment for ecosystem services provides incentives for the sustainable use of natural resources and helps preserve ecosystem services. Economic valuation provides a means of assessing the social cost and benefits associated with ecosystem services management.

The results of the economic valuation, however, should be used carefully. To that extent, they can help in performing a cost–benefit analysis of the implementation of priority actions for the conservation of this ES through instruments to be incorporated into development planning, including: (i) zoning of potential tourist areas in Madre de Dios; and (ii) the design of a payment mechanism and incentives for the conservation of natural products aimed at tourists (through a conservation fund) in Napo, Sucumbíos, and Amazonas.

Examples of prioritized instruments incorporating economic valuation results are as follows: (i) BanCO2 is a payment instrument for environmental services, promoting the creation of forest conservation markets to reduce emissions. This mechanism was implemented in Caqueta, Colombia, and its dissemination and replication was subsequently promoted. Corpoamazonía, Caqueta, led this effort, while the regional authority (Gobernación de Caquetá) opted to implement an ES payment scheme. (ii) The Water Pathway (La Ruta del Agua) association in Napo and Sucumbios was strengthened to protect local water sources and establish a financial mechanism based on payment for environmental services. This mechanism promotes the participation of the private business sector and other local actors. (iii) The study sites' ecosystem characterization and systematization led to the adoption of Ecuador's proposal to incorporate ecosystems into development plans and land use planning. (iv) In the case of Madre de Dios, Peru, the information system contributed to the development of socio-economic and environmental diagnostics.

For the department of Amazonas, the proposed priority actions for the conservation of fish as a provisioning service include promoting fisheries agreements with fishermen and communities through technology transfer and assistance, designing and implementing a communication strategy to strengthen informed decision-making on sustainable fishing, and establishing a trilateral agenda for controlling deforestation and overfishing. In contrast, in Iquitos, the priority action proposed is the development of a management plan for fish species, and policy instruments implemented so far include an inventory and mapping of basins and fishing areas, as well as a census of fishing vessels.

The participation of key stakeholders in prioritizing ES, analyzing economic valuation results, and identifying priority actions has facilitated a forum for discussion and development of capacity to propose strategies integrating ES value into development planning. Recognizing the importance of the orders of magnitude of costs and benefits associated with sustainable or unsustainable use of ES was acknowledged. Actor participation capitalized on their dual role as information generators and users, enabling an interdisciplinary environment and inter-agency perspective. The commitment and support of regional authorities in integrating ES economic valuation results into regional development plans and management tools was evident. We recommend a holistic approach recognizing interlinkages between social, economic, environmental, and institutional issues in policy formulation. The adaptive approach requires recognition of high uncertainty and feedback loops between social and ecological systems, with constant monitoring and assessment to adjust processes to achieve expected results. Comprehensive planning of productive systems and ecosystem service provision is essential for development and adapting to unexpected changes coordinated by various public and private actors.

Our participatory approach process gives five lessons learned: (i) the active participation and leadership of the regional authority institutionalizes the process; (ii) capacity building is necessary for the stakeholders to share an analytical framework which facilitates knowledge and experience exchange; (iii) share methodologies and report results to stakeholders' and value and integrate their feedback; (iv) the technical team needs to have experience not only on technical issues related to ES and policy making but also on educational didactics; (v) allocate time, and human and financial resources to accomplish the goals; (vi) limited information constrains the use of other valuation methods of ES.

Further research can contribute to the ES integration in regional development planning by assessing the effectiveness of the policy instruments implementation; identifying barriers for policy instruments implementation; and assessing welfare changes on stakeholders due to policy instruments implementation. Additionally, a better understanding of the economic valuation of ES and public policies to be enhanced is not possible without accounting for spatial and temporal dimensions [64].

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