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IMPORTANCE AND USE OF ECOSYSTEM SERVICES PROVIDED BY THE AMAZONIAN LANDSCAPES IN ECUADOR - EVALUATION AND SPATIAL SCALING OF A REPRESENTATIVE AREA

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Abstract: *The Ecuadorian Amazon region is one of the areas characterized by the greatest biodiversity worldwide. The ecosystems from the area provide many benefits to the local communities in the form of goods and services. Despite the predominance of native forests in the Pastaza Province, a deforestation rate of 7.7% and changes in land use have been recorded lately due to population growth, the reconfiguration of consumption patterns, an increase in the export of agricultural products, changes in forest legislation, agrarian reforms, and the oil extraction industry. Most likely, these changes will affect the local populations and their interaction with the local landscapes, with the poorest ones being the most affected. For these reasons, this study evaluated the use and importance of ecosystem services in the area from the local inhabitants' perspective by conducting a quantitative survey, followed by spatial scaling. While the findings indicate different importance patterns associated with different types of land uses and potential benefits, the native forests and their associated cultural services were found to be the most important for the locals. This was even more important as the spatial scaling showed the predominance of native forests and their associated services in the area. The results of this study may support a participatory approach in designing local strategies and land use policies.*

Keywords: *Ecuador, Pastaza, rainforest, ecosystem services, use, importance, spatial scaling.*

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1. Introduction

Ecosystems are considered to be “stocks of natural capital” that provide flows of tangible or intangible benefits for human welfare [12]. These benefits are commonly referred to as ecosystem services (hence forth ES) [32], and research related to them encompasses several key activities such as their identification, evaluation, valuation, as well as strategy and policy making based on the outcomes of such activities.

Since ES cover a wide range of products and services, as well as functions that sustain the ecosystems, their identification is most commonly considered to be the first step for other important activities such as their evaluation and quantification [5]. Among the existing tools and approaches to evaluating the ES, social and economic evaluations play a central role, both in science and in practice, because they have the capability to benchmark and emphasize the importance of ES to people [1], [17], in other words, to connect people to nature. In addition, according to the latest visions on ES, their underlying concepts, tools, and methodologies stand for a new approach in the decision-making processes regarding their conservation and management [15]. For this reason, research on ES has gained a significant momentum in recent years, with many studies reporting on such issues. Nevertheless, further research is still needed to cover the whole range of ES, particularly in Latin America [4], because a clear understanding of these links will provide the necessary information to guide the reform of public and private institutions and their decisions, which will ultimately improve the state of the ecosystems and the services they provide to society [21].

In this regard, Ecuador is considered to be one of the mega diverse countries in the world that is characterized by a variety of ecosystems [52] and species [30] which have a great potential to provide a wide range of ES. However, their potential is threatened by the ongoing land use change [3], a reason for which ground data is needed to evaluate or re-evaluate the current policies and to adopt wiser decisions on the use of natural capital.

In particular, the Ecuadorian Amazon region encompasses a number of 22 ecosystems [52], [70], among which forest ecosystems stand out in regards to provision of many services and products for the local communities [31], but at the same time, the region has been the subject of deforestation due to current trends in relation to land use change [6]. Even though the discovery of oil was the first cause of forest loss, the agricultural colonization that followed is considered the principal cause of deforestation in the Ecuadorian Amazon [6]. Meanwhile, deforestation affects the provision of ecosystem services [47], due to reconfiguration of trade-offs and redistributions in the potential of landscapes to provide, with the poorest communities being the most likely to be affected by such outcomes.

In this context, a good management of forested areas could be the key to meeting the challenges imposed by growing human needs, sustainable development, and the mitigation of global climate change [22], [26], [51], [55]. This is just one of the many reasons for which the importance that the local communities place on ES should be evaluated to be able to make the right decisions. Nevertheless, it is possible for the local communities to maintain and use other types of landscapes than forests in their area of living. This behaviour can be associated with many reasons, such as the need to ensure one's own provision and to maintain a positive economic balance by trade. For this reason, a more objective assessment of the ES in a given area should encompass all the land use types to be able to differentiate the importance and use of those landscapes by the locals.

The rationale behind this study is framed around the above-mentioned issues. On the one hand, the expansion of agricultural land use is in progress in the Ecuadorian Amazon region with certain impacts on the rainforest. On the other hand, there is a lack of data concerning the importance that locals place on given land use types, and an objective evaluation of ES based on the local opinion is needed to (re)design policy instruments for a sustainable use of the area. In this sense, the use of ES concepts is important in environmental management because it allows the identification of local benefits coming from a wide range of land use types.

In the above-described context, the goal of this study was to document the importance and use of direct and indirect ecosystem services by the local communities living in the Ecuadorian rainforest. To this end, a quantitative survey was designed and administrated to the population of Simon Bolívar parish, Pastaza province, Ecuador, which in many ways is a representative area of the Ecuadorian rainforest, to be able to: *i)* gain knowledge on the actual use and importance of the provisioning, regulating, and cultural ecosystem services for four types of landscape uses as being the most frequent in the area, *ii)* estimate the perceived relative importance of the ecosystem services among their groups as a prerequisite for sustainable strategies and policies formulation, and *iii)* scale up the results obtained to the area of study in order to better understand the importance of the ecosystem services in the area.

2. Materials and Methods

2.1. Study Location, Land Use, and Socio-Economic Activity in the Area

This study was carried out in the area of Pastaza Experimental Station (PS) managed by Escuela Superior Politecnica de Chimborazo (ESPOCH), which is located in the "Simón Bolívar" parish, Pastaza province, eastern Ecuador (Figure 1), at approximately 1,090 m a.s.l. [68] at 1° 43' 7.644'' S and 77° 50' 42.216'' W (UTM WGS 84).

The total area of PS is 220 ha, 40% of which corresponds to primary (native) forest, 30% is secondary (managed) forest, 1% corresponds to infrastructure, and the remaining area is pastureland [68]. To scale up this distribution at parish level, in the first category were included the native rainforests, shrubs, and herbaceous lands that are protected by law and in which human intervention is restricted to some extent [65]. For instance, timber procurement in these forests is forbidden, while the procurement of non-timber forest products is allowed by forest sector law [45]; this kind of forest is classified in the area as "evergreen lowland forest" [14]. In the second category were included forests of natural and anthropogenic origin in which the procurement of different kinds of products is allowed by law [67].

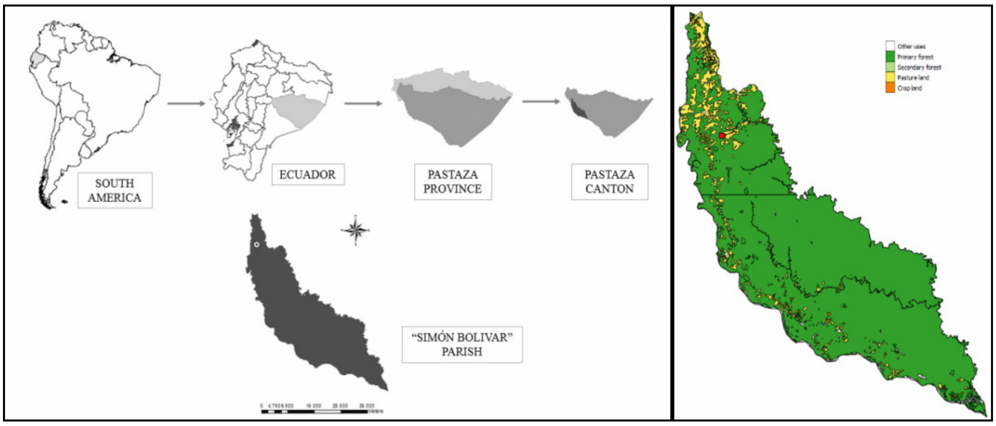

Fig. 1. *Location of PS in the Pastaza Province, Ecuador and South America, and the identified land use types. Source: prepared in ArcGIS® (left) and QGis (right) based on local layers containing the land use types and the legal aspects in relation to land use.*
Legend: *left - study location in the parish, canton, province, country, and South America; right: red square - location of PS, dark green - primary (native) forest, green - secondary (managed) forest, yellow - pastureland, orange - cropland, white - other uses, such as populated areas, infrastructure, unproductive terrains, and water bodies*

The topography of the area is rather irregular, with approximately 80% of the total area having slopes between 15 and 20% [14]. Also, the area falls under a subtropical climate [68] that is characterized by very high relative humidity (around 88%), a monthly mean air temperature of 20.6°C, and a total annual precipitation of cca. 34,333 mm [13]. In the area, the monthly air temperature varies between 18 to 27°C and the precipitation exceeds 4,500 mm [16].

The types of land use in the study area were defined and evaluated through the spatial analysis of the data that was obtained from the National System of Information [56]. This data was mapped as a first step, using the ArcGIS® software, 10.3 version (ESRI, USA) [25] to determine the area covered by different land uses and its share in the total area of the parish under study. The first documentation and understanding of the socio-economic activities in the study area were based on the Management Plan (2015-2019) of "Simón Bolívar" parish [16]. To this end, the principal activities of the economically active population were defined based on their frequency and share in the area. Collecting this data was helpful in creating the questionnaire on the use and importance of the ecosystem services in the area.

2.2. Identification of Local Stakeholders and Ecosystem Services

For the identification of the stakeholders benefiting from the ES in the study area, the methodology proposed by [63] was adapted to carry out an exploratory qualitative research that was supported by complementary techniques such as the literature review and the analysis of the websites of the involved organizations. To build a preliminary list of stakeholders, Ecuadorian legislation was analyzed because it points out the principal functions (or responsibilities) assigned to different organizations and government levels [19]. Finally, this information was complemented with the organization chart of PS and the local knowledge of ESPOCH managers, which resulted in the identification of direct and indirect beneficiaries or users of the proposed ecosystem services.

Based on the identified land use types and socio-economic activities in the area, the services that each ecosystem (or land use) could provide were established based on the information provided by the Millenium Assessment [51] and CICES [36] classifications. Based on this information, a provisional list of ecosystem services was built, then, based on several revisions, fourteen ecosystem services (Table 1) were selected for this research and classified according to MA categories [51].

List of basic ecosystem services in the area Table 1

Category of ecosystem service	Benefits of nature (ecosystem services)
Provisioning services	Food of vegetable origin (fruits, vegetables)
	Food of animal origin (meat and dairy products)
	Water for human consumption
	Water for animals
	Timber products (fuel wood and timber)
	Non-timber products (medicine, gums, waxes, latex, roots, leaves etc.)
Regulating services	Biological control
	Water quality (purification of water)
	Droughts and floods (regulation of water level)
	Biodiversity
	Purification of air (climate, carbon sequestration, etc.)
Cultural services	Recreation and tourism (hiking, photography, rest and relaxation etc.)
	Scientific field (for universities, pharmaceutical companies)
	Ancestral practices and rituals (religious ceremonies, rituals etc.)

The ecosystem services were linked to the four land uses identified in the area, with the purpose of identifying which of these ecosystems provides a particular service based on the vision and actual use by the local stakeholders.

2.3. Questionnaire Development and Field Survey

To evaluate the actual use and importance of the ES, a survey was implemented based on a face-to-face interview approach using a quantitative questionnaire. Grouping in the same item both the actual use and the importance of the ES for the local stakeholders was necessary to avoid overloading the respondents with questions, given the fact that the implemented questionnaire was much longer/more complex, as it contained several sections and items related to socio-demographic conditions, the use and importance of the ecosystem services, the visual perception on the types of land use, and the willingness to pay for the ecosystem services. Therefore, some of the methodological assumptions and procedures as described for instance, by Affek and Kowalska (2017) [1], were considered in the structure of the questionnaire. First of all, the services derived only from the local ecosystems were taken into account, and this was explicitly stated to each of the respondents during the field phase of the study. Then, the flow of ecosystem services was related to the direct consumption, in other words, only the actual uses were considered. Based on these assumptions, the questionnaire was developed by considering several sections, of which those used to get the background data for this study were the socio-demographics and the evaluation of the actual use and importance sections. The socio-demographic component was built at individual level by taking into account the list of items shown in Table 2.

The actual use and importance of the services provided by the four analyzed ecosystems were evaluated using a five-point bipolar numeric scale that was designed based on the original concepts described by Likert [43] and frequently used ever since in social and economic research. While such scales are used to measure opposite feelings and to account for attitudes [63], some studies have argued that in relation to human perception, ranking one cannot always assume an equidistance between the items on a Likert scale [46], [69]. In addition, statistical techniques used to analyze ordinal data, such as that produced by the Likert scales, are still debated on with pertinent arguments in favor of parametric statistics irrespective of data normality [57].

Nevertheless, one can avoid much of these contradictory opinions by adequately phrasing the questions. In this study, the item construct aiming to evaluate the ecosystem services use and importance assigned terms such as “low importance” to 1 and “high importance” to 5, and clearly stated that the answer should be given in relation to the importance in use, as an incremental importance from 1 to 5.

The first version of the questionnaire was tested and refined prior to its use in the field data collection using the help of personnel from ESPOCH and several other external experts. Also, the sample size was estimated before the field survey. To do that, as a first step, the current population of the study area was calculated based on the population statistics of “Simón Bolívar” parish in 2010 (5,682 inhabitants) by taking into consideration the latest reports on the population growth rate (4,91%) as well; this data was collected from the National Institute of Statistics and Censuses [39]. Even though it could overestimate the outcomes for population increment data, the exponential method as described, for instance, in [71] was used to project the population in 2019. Then, the formula of probabilistic sampling [41], [57], [75] and a confidence threshold of 95% was used to determine the sample size, resulting in a number of 368 questionnaires to be implemented in the field, standing for more than 6% of the population size. Nevertheless, in the field, a number of 451 interviews were carried out (cca. 8% of the population size), considering that certain questionnaires could be incomplete following the field exercise and/or people might not answer all the questions.

Items used to characterize the socio-demographic condition of the respondents Table 2

Item	Type	Expected answers	Forecasted coding procedure
Place of residence	Open	-	String variable
Ethnic group	Closed	Indigenous Métis White	Ordinal variable
Gender	Closed	Male Female	Binary variable
Age	Open	Exact value	Continuous variable
Civil Status	Closed	Single Married Free union Divorced Widow (er)	Ordinal variable
Education level	Closed	Elementary school incomplete Elementary school complete High school incomplete High school complete 3rd level incomplete 3rd level complete 4th level incomplete 4th level complete	Ordinal variable
Income per month	Closed	Less or equal to $394 $395 a $733 $734 a $901 $902 a $1,086 $1,087 a $1,412 $1,413 a $1,760 $1,761 a $2,034 Other	Ordinal variable
Occupation	Closed	Housewife Employee Unemployed Student Independent Retired	Ordinal variable

The field phase of the study was carried out on January 12nd 2019 with the help of 30 field researchers that were trained in advance and had an academic background in environmental engineering. The surveys were deployed using a door-to-door approach, following a random sampling based on the local house holding cadaster, and each interview lasted less than 20 minutes. To this end, the postal addresses from the area were summarized in a database and a random number sampling approach was designed in advance to derive a list of postal addresses to be approached for interview. The target population corresponded to the main beneficiaries of the ecosystem services, and it consisted of all the residents of

"Simón Bolívar" parish; however, the respondents included in the study consisted only of those over 18 years old or the heads of families.

2.4. Data Processing, Statistical and Spatial Analysis

2.4.1. General Steps Used to Process the Data

In the office phase of the study, the data coming from the questionnaires was carefully analyzed in analog form to identify possible errors or typos. Then, the data was transferred into a Spanish version of the database and organized into sections. The socio-demographic characteristics were included as attributes, based on the concept shown in Table 4, then, in specific cases, the presence of a given feature was coded by 1, while its absence was recorded as a blank cell in the database rows. Excluding the place of residence, which was coded as a string, as well as the age, which was included as an absolute value, the above described procedure was applied to all the socio-demographic data relevant for this study.

The importance and use of the ES, per main categories and sub-categories, was included using the Likert scale data and coded from 1 to 5, depending on the responses of the interviewed stakeholders. The missing data was treated as blanks in the specific cells. At this stage, to remove the errors and typos, the data belonging to each attribute included in the database was plotted against the identification number of each questionnaire. Following this step, a few cases needed rechecking of the paper format of the questionnaire and corrections. After this verification step, the textual description of the attributes included in the database was translated to English. Both versions of the database were constructed using the Microsoft® Excel® (Version 2016, Santa Rosa, California, USA) software [49].

2.4.2. Descriptive Statistics

The statistical workflow included the determination and analysis of the descriptive statistics, due to the fact that they provide information about the tendency of the data, i.e. the behavior of the respondents (sample). This section was develop dusing Real Statistics® (Release 6.2), which is a freeware plug in developed for Microsoft® Excel® [74].

For the importance and use of the ecosystem services, there were determined the following descriptive statistics: minimum, maximum, mean, and median values; while the socio-demographic data was analyzed using only the techniques of absolute and relative frequency (number of observations per attributes and categories). Finally, all the descriptive statistics were interpreted and discussed based on the literature review.

2.4.3. Data Aggregation and Estimation of Importance

Given the large number of ES sub-categories and the aim of the study which was to estimate the importance of these ES at land use type and scale, some sort of data aggregation was necessary. To this end, the importance of an ecosystem service category may be assessed in different ways, including the use of social investigation techniques and mapping methodologies [10], [38], [48].

In this study, the problem was approached by estimating the importance and actual use of the ES following data aggregation and computation of a relative importance at two scales. The first scale was framed around the landscape type and the ES category, and at this level of division, the respondents' ratings were used to compute the relative importance of the ecosystem services. To achieve this, as a first step, the scores given by the respondents (1 to 5) to specific sub-categories of ecosystem services included in the provisioning, regulation, and cultural categories were aggregated by summation at landscape type level, resulting in data aggregated for the four landscapes and the three categories of ecosystem services considered, as shown in Table 3. The same procedure was used to aggregate data at landscape level - standing for the most general scale of the area - irrespective of the ecosystem service category (Table 3).

Ecosystem services categories, land uses, and metrics computed in this study Table 3

Ecosystem service category	Landscape use type	Abbreviation of aggregation score	Abbreviation of relative importance
Provision	Unmanaged (primary) forest	AS_{PUF}	RI_{PUF}
	Managed (secondary) forest	AS_{PMF}	RI_{PMF}
	Pastureland	AS_{PP}	RI_{PP}
	Cropland	AS_{PC}	RI_{PC}
Regulation	Unmanaged (primary) forest	AS_{RUF}	RI_{RUF}
	Managed (secondary) forest	AS_{RMF}	RI_{RMF}
	Pastureland	AS_{RP}	RI_{RP}
	Cropland	AS_{RC}	RI_{RC}
Cultural	Unmanaged (primary) forest	AS_{CUF}	RI_{CUF}
	Managed (secondary) forest	AS_{CMF}	RI_{CMF}
	Pastureland	AS_{CP}	RI_{CP}
	Cropland	AS_{CC}	RI_{CC}
Total	Unmanaged (primary) forest	AS_{TUF}	RI_{TUF}
	Managed (secondary) forest	AS_{TMF}	RI_{TMF}
	Pastureland	AS_{TP}	RI_{TP}
	Cropland	AS_{TC}	RI_{TC}

Then, the relative importance (Table 3), as one of the main metrics of this study, was computed by considering the same scales. For each respondent, the relative importance of the provisioning ecosystem services for a given landscape use was computed as the ratio of the score corresponding to that landscape use type to the sum of scores (i.e. scores for all the landscape use types) in the provisioning ecosystem services category. The same procedure was used to compute the relative importance for the rest of the ecosystem services categories and land uses. At landscape use scale, the relative importance was computed in a similar way by adding all the scores irrespective of the ecosystem service category.

The approach described above has the advantage of estimating the importance of a given category within a framework or scale to which it is reported and may be easily interpreted as a share of importance if multiplied by 100. At the same time, it allows to differentiate the outcomes relative to a given category; therefore this metric may stand for a good approximation of a feature's importance within the category to which it belongs. Following these steps, the data was analysed by means of descriptive statistics. A first step consisted in reporting the main statistics for all the scales taken into consideration, while the second step consisted of a data synthesis using the average values.

The outcomes of this synthesis were also used for the spatial scaling of the use and importance of the ecosystem services.

2.4.4. Spatial Scaling

The spatial scaling analysis consisted in extrapolating the results of the relative importance to the area understudy using a GIS approach that used the spatial layers (.shp) already available for the land use types. While in many cases statistical extrapolation has its own limitations [75], in the case of spatial analysis, and especially for the area under study, it was considered to be a fair approach in expressing the importance and use of the ecosystem services since the relative importance computed by the procedures given above is, in essence, an nondimensional index. Therefore, scaling the outcomes of the relative importance to the area under study would help in understanding the extent of the phenomenon in the area and it could probably be extended to most of the Ecuadorian rainforest, given the characteristics of the population sample included in the study. The outcome of such an approach would also indicate the area to which a given importance level was attributed, most probably helping in designing policies and allocating funds. To do that, the typical steps consisted in building five more attribute columns in the spatial database, associated to the area under study, one of which consisted of the land use type coded from 0 to 4, where 0 stands for "other uses", 1 for primary forest, 2 for secondary forest, 3 for pastureland, and 4 for cropland. Then, based on the logical functions written in the Field Calculator of the QGis 3.4.13 software (2018 Madeira, *GNU - General Public License*) for geographic information system, developed by an open source geospatial foundation project, the remaining four attribute columns were populated by data on the relative importance associated to all the ES taken together (global importance), as well as to the three categories: provisioning, regulating, and cultural. Based on this framework, four maps were created to show the importance and use of the ESs, and data on the corresponding area was queried and reported for each map.

3. Results and Discussions

3.1. Socio-Demographic Characteristics

As shown in Table 4, from the respondents surveyed, the predominant ethnic groups (73.82 and 23.7%, respectively) were represented by the métis and the indigenous. However, 14 subgroups were included in the group self-identified as indigenous, as reported in [17].

The proportion of male and female respondents was equitable and the majority of respondents (63.84%) were between 26 and 55 years old. According to [24], the above-mentioned finding is comparable to the national average age of the economically active population in labour capacity (66.80%). In terms of civil status, there was a 5.88% difference in the proportion of those living as a couple (married and free union) compared to those living alone (single, divorced, and widowed). Most respondents (82%) declared the accomplishment of secondary or lower education levels. More than half of the respondents declared themselves to be economically active (58.31%), while an important proportion was that of house wives, which are not considered part of the economically active population by the Ecuadorian law, thus underestimating their labour participation [40]. Almost 72% of the respondents declared an income level less than or equal to the unified basic salary which is used to feed data on the annual projected inflation and labour productivity [53].

3.2. Importance and Use of Ecosystem Services

3.2.1. Importance and Use of Ecosystem Services by Subcategories

As shown in Table 5, the provision of food of vegetal origin was perceived to have the highest value in crops, while the lowest value was assigned to pasturelands.

This was probably related to the local custom in which the population bases its food provisioning on a self-consumption economy [35].

Unmanaged (primary) native forest was found to have the highest average and median values related to the use and importance of environmental services such as water for human consumption and livestock, timber and timber derivatives, and also for non-timber forest products. These findings are in full accordance with the Ecuadorian strategic plan on native forests, which analyses the factors that are considered to have a relevant strength for this forest type [23], acknowledging that the uses of forest plant species are important for the sustainable use of forest ecosystem provisioning services [31]. Foods of animal origin such as meat, milk, and their derivatives were given the highest average and median values in the case of pasturelands, acknowledging the importance they have as the main source of primary production (5 and 7 species of grass and legumes, respectively) in the Amazonian ecosystems [34].

Socio-demographic characteristics of the respondents Table 4

Socio-demographic feature	**Number of respondents**	**Share in the sample (%)**
Ethnicity		
Indigenous	105	23.70
Métis	327	73.82
White	11	2.48
Other	-	-
Gender		
Male	223	49.56
Female	227	50.44
Age		
Less than 25(early age)	123	27.45
26 to 35 (young adults)	129	28.79
36 to 55 (mid-aged adults)	142	31.70

Socio-demographic feature	**Number of respondents**	**Share in the sample (%)**
56 to 60 (close to retirement)	15	3.35
Over 60 (retired)	39	8.71
Civil status		
Single	164	37.10
Married	144	32.58
Common Union	90	20.36
Divorced	27	6.11
Widow(er)	17	3.85
Level of Education		
Primary incomplete	35	7.78
Primary complete	117	26.00
High school incomplete	79	17.56
High school complete	138	30.66
Third level incomplete	39	8.67
Third level complete	36	8.00
Fourth level incomplete	1	0.22
Fourth level complete	5	1.11
Income		
≤394 $	323	71.62
395-733 $	73	16.19
734-901 $	21	4.65
902-1,086 $	6	1.33
1,087-1,412 $	9	1.99
1,413-1,760 $	3	0.67
1,761-2,034 $	1	0.22
Occupation		
Housewife	114	25.28
Employee	115	25.50
Freelancer/entrepreneur	148	32.81
Unemployed	10	2.22
Student	54	11.97

Descriptive statistics on the importance and use of provisioning ecosystem services Table 5

Ecosystem services category, subcategories, and type of ecosystem	**Number of respondents**	**Minimum Value**	**Maximum value**	**Average value**	**Median value**
Provision of					
Food of vegetal origin from					
Unmanaged (primary) forest	408	1	5	3.92	4
Managed (secondary) forest	395	1	5	3.04	3
Pastureland	314	1	5	2.58	2
Crops	431	1	5	4.16	5
Food of animal origin from					

Ecosystem services category, subcategories, and type of ecosystem	**Number of respondents**	**Minimum Value**	**Maximum value**	**Average value**	**Median value**
Unmanaged (primary) forest	347	1	5	3.14	3
Managed (secondary) forest	352	1	5	2.58	3
Pastureland	439	1	5	4.25	5
Crops	312	1	5	2.47	2
Water for human use from					
Unmanaged (primary) forest	433	1	5	4.49	5
Managed (secondary) forest	414	1	5	3.40	3
Pastureland	321	1	5	2.51	2
Crops	346	1	5	2.79	3
Water for animal use from					
Unmanaged (primary) forest	399	1	5	4.34	5
Managed (secondary) forest	389	1	5	3.36	3
Pastureland	379	1	5	3.69	4
Crops	326	1	5	2.90	3
Timber and timber derives (derivatives?) from					
Unmanaged (primary) forest	422	1	5	4.41	5
Managed (secondary) forest	427	1	5	3.94	4
Pastureland	273	1	5	1.87	1
Crops	304	1	5	2.31	2
Non-timber products from					
Unmanaged (primary) forest	414	1	5	4.33	5
Managed (secondary) forest	396	1	5	3.37	3
Pastureland	286	1	5	2.01	2
Crops	372	1	5	2.98	3

The indigenous communities which are located closest to protection and conservation areas preserve the forms of management, ancestral knowledge, and non-extractive cultural use of their territory and biodiversity [2]. Parts of these are emphasized by the descriptive statistics given in Table 6, that stand for the use and importance of the regulation services in unmanaged forests, such as water quality, biodiversity, and purification of air. Biological control is associated with productive plant resources for self-subsistence (grass and crops), so in both cases the value of importance assigned on a scale from 1 to 5 was 4.

As shown in Table 6, the importance of the environmental services evaluation lies in the current problem on climate change and biodiversity reduction, acknowledging the need to think globally, but act locally [18], [37], [51], 62]. It should be noted that, although indigenous communities usually have a worldview that includes the care of the forest [8], this does not mean that they will engage in contemporary conservation initiatives [72]. Nevertheless, formal forest conservation [48] is framed around new languages such as biological conservation, sustainability, and ecosystem services, allowing multiple-scale governance schemes to operate [9].

Table 6

Descriptive statistics on the importance and use of regulating ecosystem services

Ecosystem services category, subcategories, and type of ecosystem	Number of respondents	Minimum Value	Maximum value	Average value	Median value
Regulation of (or by)					
Biological control provided by					
Unmanaged (primary) forest	294	1	5	3.14	3
Managed (secondary) forest	342	1	5	2.90	3
Pastureland	376	1	5	3.47	4
Crops	406	1	5	3.77	4
Water quality by					
Unmanaged (primary) forest	401	1	5	4.49	5
Managed (secondary) forest	390	1	5	3.51	4
Pastureland	328	1	5	2.31	2
Crops	350	1	5	2.67	3
Water regulation by					
Unmanaged (primary) forest	313	1	5	3.09	3
Managed (secondary) forest	353	1	5	2.93	3
Pastureland	341	1	5	3.07	3
Crops	364	1	5	3.35	3
Biodiversity by					
Unmanaged (primary) forest	436	1	5	4.63	5
Managed (secondary) forest	407	1	5	3.62	4
Pastureland	362	1	5	2.83	3
Crops	365	1	5	2.90	3
Purification of air by					
Unmanaged (primary) forest	417	1	5	4.63	5
Managed (secondary) forest	402	1	5	3.75	4
Pastureland	318	1	5	2.43	2
Crops	357	1	5	2.85	3

Note: * the sampled data did not follow a normal distribution

Natural resources from the area resulted in landscapes with high aesthetic, ecological, and cultural values [61] that are used by the local inhabitants and typically attributed as important to the native forests, as shown in Table 7. A special feature of these services is that they evolve and are interrelated with social systems. From this point of view, the rural communities and the local ecosystems are strongly interdependent [11], [27], and the rural communities are characterized by a well-developed system of tacit ecological knowledge that enables them to assess the quality of the goods and services provided by the ecosystems and to sustainably manage the natural systems [54], [59], [73].

Table 7

Descriptive statistics on the importance and use of cultural ecosystem services

Ecosystem services category, subcategories, and type of ecosystem	Number of respondents	Minimum Value	Maximum value	Average value	Median value
Cultural services as					
Recreation and tourism used in or provided by					
Unmanaged (primary) forest	404	1	5	4.13	5
Managed (secondary) forest	408	1	5	3.56	4
Pastureland	322	1	5	2.36	2
Crops	352	1	5	2.65	3
Scientific ground used in or provided by					
Unmanaged (primary) forest	397	1	5	4.34	5
Managed (secondary) forest	376	1	5	3.34	3
Pastureland	323	1	5	2.89	3
Crops	342	1	5	2.99	3
Ancestral and spiritual experiences provided by					
Unmanaged (primary) forest	360	1	5	4.09	5
Managed (secondary) forest	347	1	5	3.14	3
Pastureland	246	1	5	1.84	1
Crops	272	1	5	2.21	2

Note: * the sampled data did not follow a normal distribution

Since the industrial activity in the region is still low, the opportunities for stable jobs are poor, and the rural inhabitants typically practice subsistence farming due to the lack of other options at local and regional level [50]. Therefore, most people from the studied area still rely heavily on the traditional provision of ecosystem services in their daily lives [27], [50].

3.2.2. Relative Importance and Use of Ecosystem Services on Landscapes

Figure 2 shows the distribution of data by considering the relative importance and the scales under study. Irrespective of the scale considered for the study, the ecosystem services provided by the native (unmanaged) forests were found to have the highest use and importance based on the respondents' ratings. They were followed by managed (secondary) forests, croplands, and pasturelands. At the same time, native forests were found to have the highest relative importance in the cultural ecosystem services category, followed by provision and regulation. Even if statistically interpreted as outliers in some cases (Figure 2), there were situations in which the respondents gave full importance to given landscape uses, and in most of the cases, the mean values were close to the median ones.

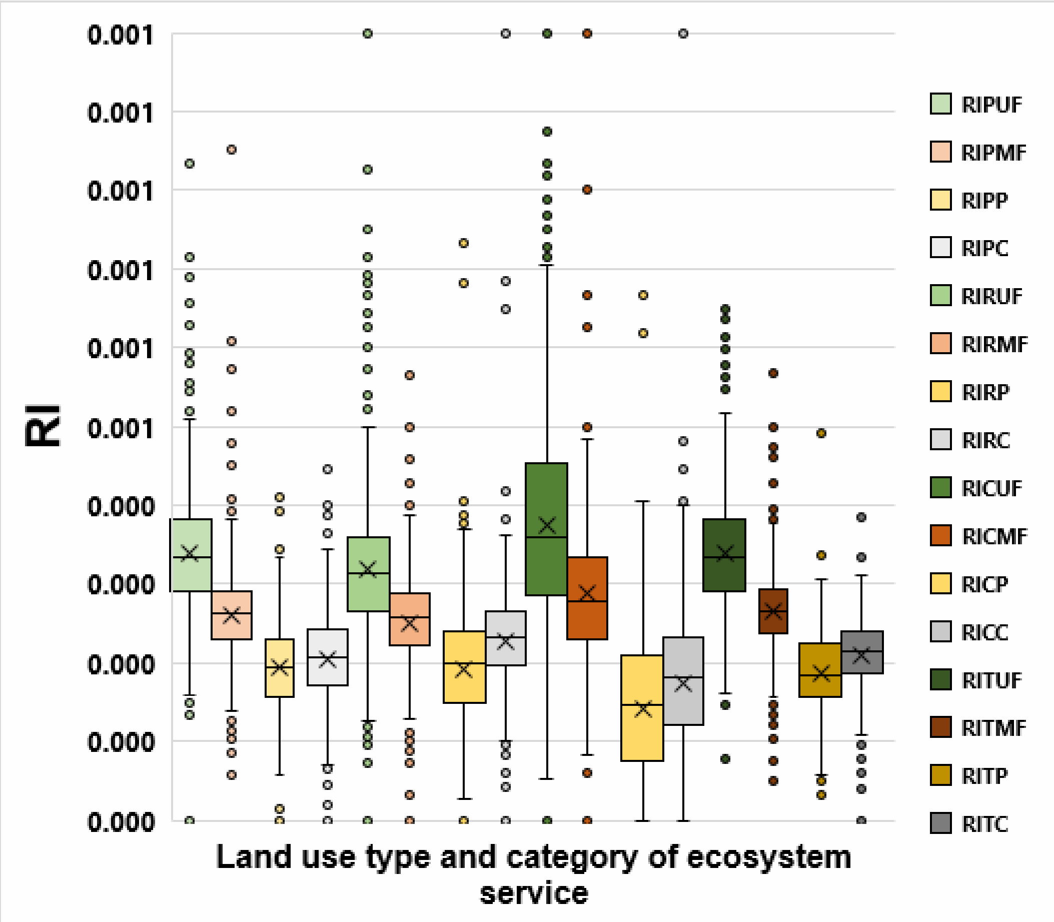

Fig. 2.*Descriptive statistics of the relative importance per land use and ecosystem service category*

Legend: *RI - Relative Importance of P - Provision, R -Regulation, C – Cultural and Overall (T) services for (UF) - Unmanaged Forests, (MF) - Managed Forests, (P) - Pasturelands, and (C) – Croplands*

For this reason, the average values of the relative importance were used, as shown in Figure 3, to rank the importance of the ecosystem services at the chosen scales. At general landscape level, the most important group was that of unmanaged forests, accounting for more than one third of the general importance (34%), followed by managed forests and croplands (26.4% and 21.70%, respectively). The lowest importance and use were found in the case of pasturelands (18.70%). Nevertheless, in the category of cultural ecosystem services, the native forests were found to have a relative importance of close to 40%, mainly on the expense of crop and pasture lands. Also, taken together, the forests accounted for a relative importance higher than 50% (and higher than 60% by excluding the regulation ES) at all the scales under study.

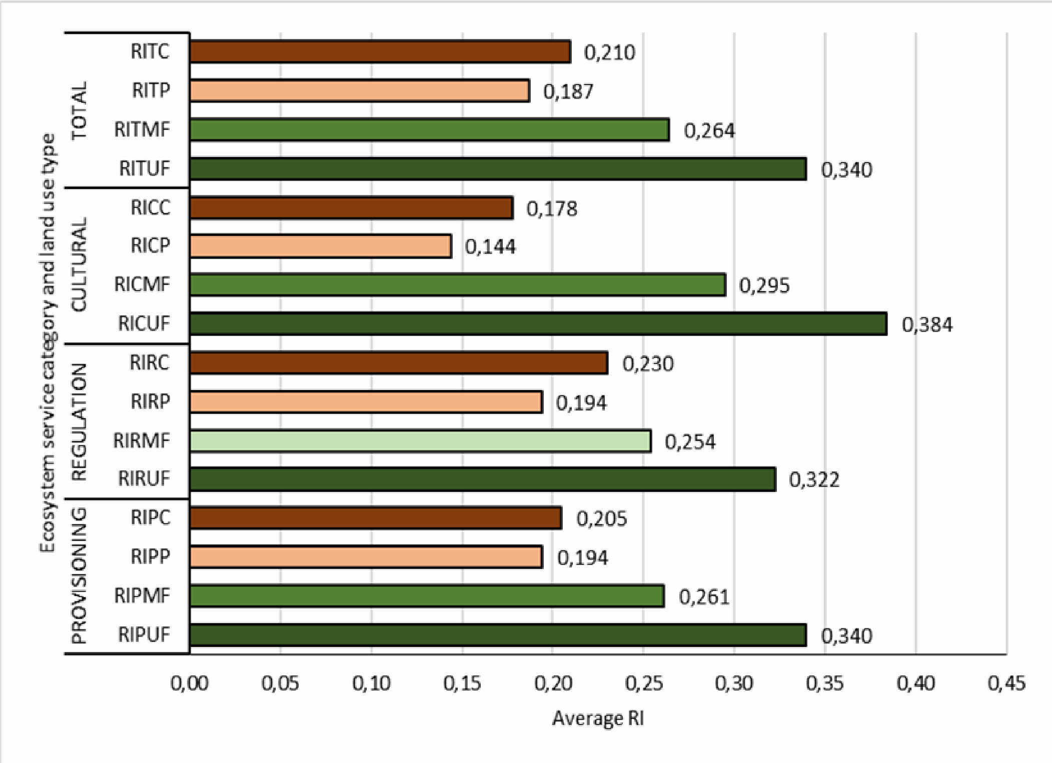

Fig. 3. *Relative importance and use per ecosystem services categories and land use types*

Legend: *RI - Relative Importance of P - Provision, R - Regulation, C – Cultural, and Overall (T) servicesfor (UF) - Unmanaged Forests, (MF) - Managed Forests, (P) - Pasturelands, and (C) - Croplands*

Unfortunately, it was not possible to compare these findings with other results, since there are no similar studies which consider the relative importance of ES. In addition, ES are dependent on biotic and abiotic factors within a specific study area, a fact that might limit the comparability even in such a case in which similar results would have been available.

3.2.3. Spatial Scaling

The results on the relative importance scaling are given in Figure 4, showing a relatively similar pattern in regard to the importance of the ecosystem services, irrespective of the ecosystem service category.

Nevertheless, important redistributions of data appeared in the cultural ecosystem services which received a higher relative importance (i.e. Table 8), in the case of primary and secondary forests at the expense of pasture and crop lands.

Data shows, however, that primary forest which accounted for most of the territory received a relative importance greater than 0.3 (more than 30%) in all the cases. By scaling the results as a function of the area covered by the land use types, the results are shown in Table 8, excepting here the category of other land use types.

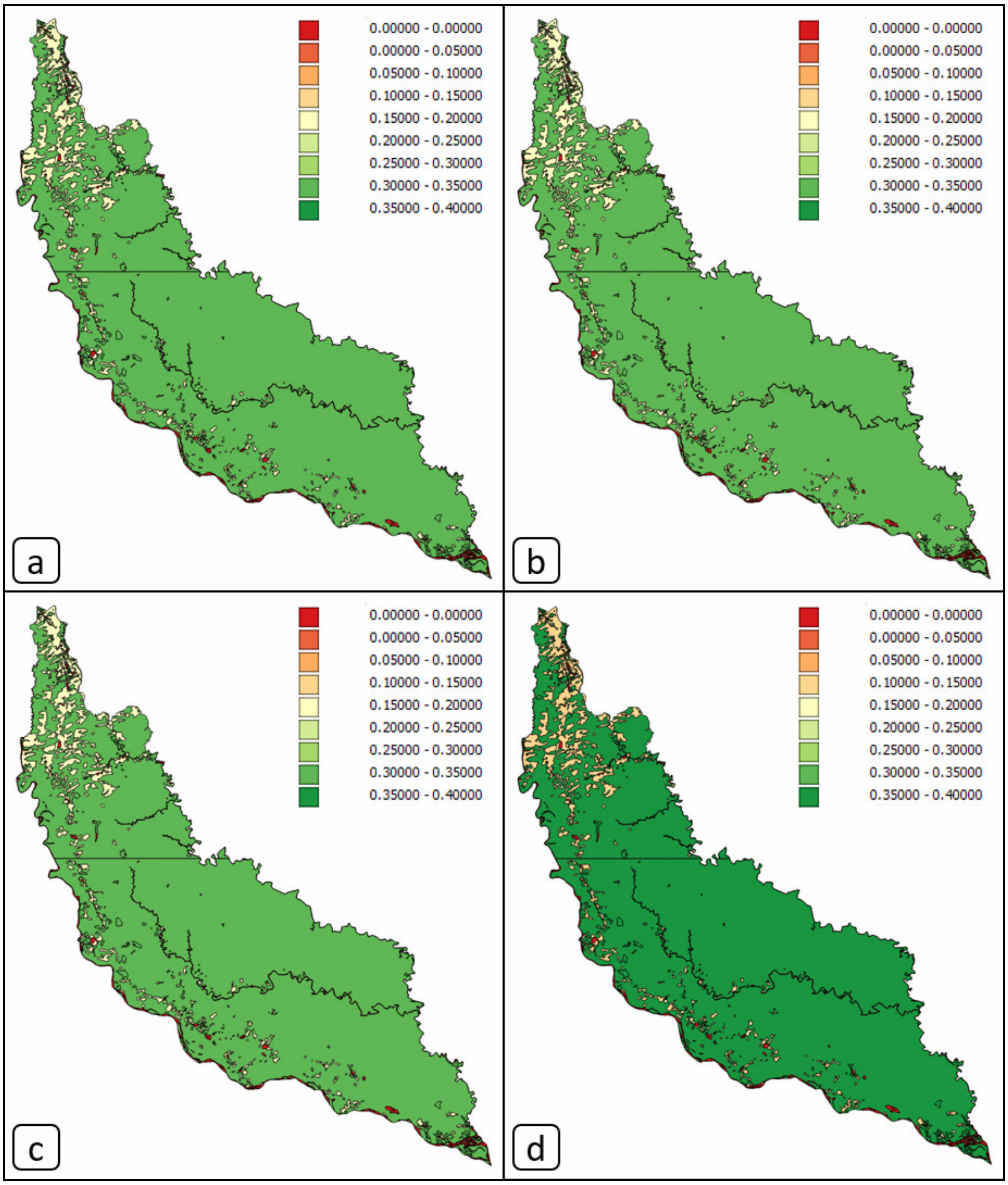

Fig. 4. *Importance and use of ecosystem services by spatial scaling*

Legend: *a) relative importance of ecosystem services irrespective of the ecosystem service category, b) relative importance of provisioning ecosystem services, c) relative importance of regulating ecosystem services, d) relative importance of cultural ecosystem services (where relative importance may take values between 0.1 and 1)*

As shown in Table 8, the weighting of the area covered by different land use types translated the data in quite a different distribution, with higher ratings associated with primary forest, which ranged between 0.954 - 0.970 (95.4-97.0%). The secondary forest seemed to lose much of its weighted importance, given the fact that the area covered by this type of forest was the smallest?. Acknowledging the limitations of using an area weighting procedure to show the importance of different land use types (e.g. punctual iconic landscapes may produce other distributions in relation to their location), these results are the only ones that could be produced given the available data.

Even in this case, the ranking of importance kept the primary rainforest at the top. At a glance, interested parties could judge the data based on the relative importance given by the respondents (Figure 4), which is important. Nevertheless, people often lack the ability to scale up their ratings when evaluating something larger that cannot be seen during the evaluation, while the relationships that they maintain with landscapes appear to be particularly important [33] as the awareness of the services provided by a certain region or land use is increasing [44], being crucial to show the real importance of a landscape.

Importance of ecosystem services scaled at study area level by area weighting Table 8

Importance of ecosystem services	Area of land use*	Relative importance	Scaled importance** [%]
General			
Unmanaged (primary) forest	92,716.38	0.340	95.777
Managed (secondary) forest	46.44	0.264	0.037
Pastureland	6,831.84	0.187	3.882
Crops	477.35	0.210	0.305
Provisioning			
Unmanaged (primary) forest	92,716.38	0.340	95.645
Managed (secondary) forest	46.44	0.261	0.037
Pastureland	6,831.84	0.194	4.021
Crops	477.35	0.209	0.297
Regulating			
Unmanaged (primary) forest	92,716.38	0.322	95.377
Managed (secondary) forest	46.44	0.254	0.038
Pastureland	6,831.84	0.194	4.234
Crops	477.35	0.230	0.351
Cultural			
Unmanaged (primary) forest	92,716.38	0.384	97.049
Managed (secondary) forest	46.44	0.295	0.037
Pastureland	6,831.84	0.144	2.682
Crops	477.35	0.178	0.232

Note: * Not shown: area of other land use types (2,000.67 ha). ** Not shown: the scaled importance of other land use types (assumed to be 0).

In what regards the use of ecosystem services, of great concern is that respondents associated the provision of timber (Table 5) with primary forest, meaning that they either use this product from the forest even if it is against the law [28] or just consider it important. An explanation for this outcome could be the way that people formulated their mind construct about the primary forest when answering: in terms of importance or in terms of use. Nevertheless, the growing social demand for timber forest products is covered by an increase in the volume of wood obtained from natural and planted forests [29], while the environmental consequences of the increasing extraction of timber in the area may be, among others, the loss of biological diversity, increased deforestation, promotion of erosion, and contamination of water bodies [42], which could be avoided by using the latest initiatives aiming to improve the practice of natural resources utilization [20]. These include the conservation of biological diversity, as well as the maintenance of environmental goods and services that the forest naturally provides [7], [58], [66]. On the other hand, the landscape sustains the formation of indigenous communities [64] whose inhabitants can operate as promoters of biological protection [7]. In addition, a management that involves a wise use of wood or other forest products has more advantages for conservation than a pasture or a crop [60]. To summarize, if the responses described the importance, then probably the sustainability of native forest ecosystems will not be affected. If the second option is true, which is also more likely given the distribution of respondents per categories of income and employment (Table 4), then measures should be taken to ensure sustainability. Since this could be achieved by creating new or better paid jobs, one option would be developing a local economy that should ensure the resilience of local ecosystems (e.g. tourism). Another option would be to develop the current economic practices to an extent that would not compromise the resilience of the local forest.

4. Conclusions

This study brings evidence on the use and importance of Ecuadorian rainforest ecosystems and land use types for local inhabitants by a wide exercise of sampling and data analysis, also showing the importance of ecosystem services by spatial scaling. The main conclusions that could be extracted are the following:

i.) The native rainforest is of great importance and provides ecosystem services that are used by the locals, and covers the main categories of tangible services as described by the literature: provisioning, regulating, and cultural;

ii.) While the second importance was placed on the managed forest, its weighting by the area covered resulted in a lower degree of importance in this study. However, this outcome should be treated with caution since in other areas, the presence of managed forests could be significantly higher;

iii.) Special attention should be given to the economic development in the area by implementing measures tailored to native forest protection and the social condition of the inhabitants.

Moreover, the obtained results might be complemented by means of inferential statistics to analyse the possible influence of social factors.

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