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A Cost–Benefit Analysis for the Economic Evaluation of Ecosystem Services Lost Due to Erosion in a Mediterranean River Basin

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Abstract: Soil degradation in Europe is mostly represented by soil erosion that, as a sediment production mechanism, is the main environmental threat to many watersheds, including the Bovilla watershed (Tirana), useful for the supply of drinking water to the city, and therefore, the care of water quality is of particular interest. The soil erosion of the Bovilla watershed was monitored in a work set up in June 2017. Following this work, this research updates the previous data on soil loss at the Bovilla watershed in t/ha/year to September 2019 and focuses on the identification and monetary evaluation of the ecosystem services (ESs) linked to soil erosion (loss of carbon, loss of mineral elements, habitat quality, crop productivity, and sustainable tourism suitability). Then, we applied the replacement cost analysis to test the economic convenience and suggest the adoption of sustainable land management practices (e.g., reforestation) able to improve the quality water in this watershed. The study carried out demonstrates that the values of soil lost due to erosion vary depending on the type of land use (ranging from average values of 120.32 t/ha for bare land to values of 8.16 t/ha for wooded areas). Furthermore, from the application of monetary methods for the evaluation of some ecosystem services linked to erosion (loss of carbonaceous and mineral elements, habitat quality, productivity, suitability for sustainable tourism), it clearly emerges that the value of the productivity of agricultural crops varies from EUR 0 to 35,320.50/ha and that the service represents a more incisive service than the previous ones, so much so as to make the conversion of some agricultural land with high productivity values into wooded areas economically disadvantageous. The data from this study may help to develop Bovilla watershed management strategies for erosion and pollution control and sediment remediation mainly in agricultural lands. A program of measures can be effective for controlling soil erosion, but it must be implemented over long time frames, and it requires relevant investments from the public and private sectors, also with a view to increase the allocation of economic values of monetary compensation aimed at those who decide to start forestation projects on highly productive soils.

Keywords: Mediterranean area; soil erosion; land productivity loss; monetary evaluation; soil ecosystem services; watershed management; payments for ecosystem services

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1. Introduction

Soil is a complex system within which a series of physical and biochemical processes are located that are vital for the characteristics of soil including the numerous species that live inside guaranteeing biodiversity and health for our globe [1], allowing the soil/plant system to produce biomass, monitor nutrient balance, and permit chemical recycling and water storage [2]. As for the environment in a global sense, soil can also be considered a natural capital considered as a resource capable of expressing, with goods and services, its profitability also in the future [3]; therefore, in addition to the biomass produced, ecosystems are able to perform a variety of services, defined by the literature of interest as ecosystem services (ESs), capable of providing public goods [4].

Anthropogenic pressure and above all human activities have exerted pressure leading to the degradation of soil functions, highlighting processes such as erosion, a decline in organic matter; local and diffuse contamination; sealing; compaction; a decline in biodiversity; salinization; floods; and landslides [5].

There is rich scientific literature that highlights how the erosive process is related to the loss of ecosystem services [6–8] and the strategies to be adopted to combat it, in response to the CAP and the 2030 Agenda SDGs [9]. The European Commission also defines measures to protect and restore soils and ensure that they are used sustainably in the approval document of the "Soil Strategy for 2030". The main objective is to ensure that, by 2050, all member states of the European Union avoid consuming land (zero net land take) and ensure that their soils are "healthy" through concrete actions, to be implemented by 2030. The EU Soil Strategy also aims to ensure the following by 2050:

- All European soils are healthy and more resilient and can continue to provide their fundamental services (ecosystem services);
- Net land consumption is reduced to zero, and soil pollution is brought back to levels that are not harmful to people's health or ecosystems;
- The soils are protected and managed in a sustainable way, also restoring those currently degraded.

The document also indicates a series of fixed points and actions to be implemented in the coming years, such as the following:

- The presentation of a European law for the protection of soil health, which incorporates all the contents of the strategy;
- Sustainable soil management, i.e., a European soil management practice, promoted through specific actions of the Community Agricultural Policy, aimed at sharing and developing the best agronomic management practices, and through free soil analysis agricultural campaigns;
- Encourage the accumulation of organic carbon in soils to mitigate the effects of climate change, including through legislative actions that protect and constrain wetlands and organic soils;
- The prevention of desertification through the development of a common methodology to evaluate its level and prevent land degradation [10].

In recent years, the evolution of lifestyles, food needs, and, consequently, agricultural techniques and the exacerbation of climate change have caused an increasingly negative impact on the soil [11], highlighting the inability of soils to continue to guarantee food security and conditioning their ability to maintain the quality and quantity of ESs supplied, requiring more sustainable soil management [12,13]. In fact, the sustainability of the management of these ecosystems (forests, agricultural, and urban areas) passes from the essential relationship that exists between the natural soil capital and the ESs that it is able to provide, such as, the contrast to the degradation and impoverishment of soil fertility in forest systems, crop rotations, and minimum tillage techniques in agricultural areas, together with the ability of non-degraded soils to preserve and accumulate organic matter, water, and micronutrients, regulate greenhouse gas emissions, and increase resistance to pests and diseases [14]. On the other hand, all these excellent capacities are threatened by the adoption of highly intensive cultivation systems and practices to meet the ever-increasing food needs of humans and animals: this behavior has the consequence of reducing the ability of natural soil capital to provide positive externalities and to be essential for the sustainability of ecosystems and communities [15]. Non-sustainable land uses are always linked to disservices (loss of biodiversity, acidification erosion, nutrient losses, etc.) that affect soil productivity and, consequently, cultivation quality and yields, affecting the profitability of agricultural activity [16,17].

According to the EU, these essential soil functions are under several degradation pressures due to human activities. These degradation pressures include erosion; a decline in organic matter; local and diffuse contamination; sealing; compaction; a decline in biodiversity; salinization; floods; and landslides [5].

One of the most dangerous causes of soil degradation is erosion. Soil erosion causes not only the loss of land but also water pollution. Many factors are the basis of soil erosion: the geological structure, climate, morphology, lack of vegetation cover, and structure of land use. Solid and organic matter are transported through surface and ground water and are the main cause of a reduced volume of water in the basin and at the same time are the main pollution factors for the water and the environment.

Scholars have carried out research on modelling soil erosion rates under different climate and land use conditions [18,19].

The impoverishment of the soil, and therefore of the ESs related to it, inevitably causes negative impacts on productivity; the above could lead to risks of extremely high restoration costs [16,17] and therefore further degradation and economic devaluation.

The economic value of soil biodiversity stems from the idea that it can be valued as a natural capital asset, from which a flow of soil ecosystem services is produced [20,21]. Furthermore, each of these negative externalities also affects social well-being; in fact, a reduction in soil biodiversity can generate effects on the cost of environmental mitigation and on the increase in production costs, which are essential to counteract the loss of productivity. The adoption of all these sustainable techniques can generate long-term positive impacts by strengthening the role and effects of ESs [22,23].

ESs have been classified using different schematizations [4,24,25], which have in common the division into four categories: production/provisioning services, regulating services, habitat/supporting services, and information/cultural services, as reported in Table 1. Furthermore, in the literature, there are other more specific classifications both in soil-specific [11,26–35] and agroecosystem contexts [36–40] (Table 1).

Table 1. Soil ES classification quoted from the Millenium Ecosystem Assessment. (Source: authors' elaboration of [4]).

Description and Meaning	Category
Products people obtain from ecosystems, such as food, fuel, fibers, and fresh water.	Provisioning services
The benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of human diseases, and water purification.	Regulating services
The non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences.	Cultural services
Services that are necessary for the production of all other ESs, such as primary production, production of oxygen, and soil formation.	Supporting functions

The concept of payments for ecosystem services (PESs) requires that landowners and land users be compensated for providing a service to society, such as water flow regulation, the seizure of carbon, biodiversity conservation, etc. [41], adopting practices to ensure ecosystem conservation and rehabilitation [42].

Here, the focus is on shedding light on the role of the economic valuation of ecosystem services linked to soil loss in a study area represented by the Bovilla watershed to allow such values to be made explicit to society in general and policy-making in particular.

The Bovilla watershed constitutes the main reserve source of drinking water for the city of Tirana, and part of the water is also used for the irrigation of crops cultivated in that area. A report from the Albania National Forest Inventory from 2004 showed that the land cover/use is changing especially in the sloping and hilly areas in favor of cultivated areas. This may mean that this change occurred in less favorable environmental conditions (e.g., shallow soils, slopes, difficult to access, etc.). As a result of improper land use practices in the watershed, soil erosion has become an inhibiting factor for the sustainable development of agriculture and the conservation of natural resources including water resources.

Soil degradation is an issue of growing concern in Europe because 12% of the total European land area has been affected by water erosion and 4% by wind erosion [43]. The studies conducted in this area have investigated soil erosion through the application of the RUSLE model at a basin scale and a timely soil loss monitoring activity [42]. In fact, twenty-five plots (≈65–100 m^2) were installed under different slope (10–20%, 21–40%, 41–60%, and >60%) and land cover (forest, pasture, agricultural, orchard) conditions and were used to measure the amount of sediment and runoff from June 2017 to May 2018 in previous work [44], and this was updated until September 2019 in the present study. This research focuses on identifying and evaluating the possibility of establishing schemes for payments for ecosystem services (PESs) in the Bovilla watershed (Tirane, Albania) to promote the adoption of sustainable land management practices that will result in improved quality water in this watershed.

This research aims to provide an update on the previous works in the Bovilla [44] watershed in order to (1) update the data of soil loss in/t/ha/year of the Bovilla watershed from June 2018 till September 2019, (2) monetarily estimate the ecosystem services linked to the erosion of the Bovilla basin, and (3) suggest an implementation of PESs in particular for the sub-watersheds Ranxe, Vilez, and Zall-Bastar that were selected as critical erosion areas and the main hotspots [45], which contribute to about 65% of the sediment yield of the watershed. The data from this study may help to develop Bovilla watershed management strategies for erosion and pollution control and sediment remediation mainly in agricultural lands. To achieve these research objectives, using the first results on Bovilla soil loss and the erosion map published by the authors of [44], we identified the main ecosystem services directly and indirectly linked to soil erosion, we assessed and monetarily quantified these ecosystem services, and finally, we compared the soil loss to the basin restoration strategies (e.g., reforestation) through a cost–benefit analysis.

2. Materials and Methods

2.1. Study Area

The study area is in the north-eastern part of Tirana city (Figure 1), with a width of 95 km^2, belonging to the Tirana (52.2 km^2) and Kruja (39.8 km^2) municipalities.

The Bovilla reservoir is 15 km away from Tirana city with a maximum water filling capacity of 80 million m^3. The total area of the Bovilla reservoir is 4.6 km^2, and the maximal depth is 53 m. The potable water volume of the Bovilla reservoir is estimated at about 55 mln m^3/year, and the rest might be used for irrigation. The Bovilla watershed comprises six sub-watersheds (Table 2).

Table 2. Description of each sub-watershed in the study area.

Sub-Watershed	Area (ha)	Slope (degree)	Elevation (m) a.s.l.	
			Min	Max
Bovilla reservoir	345.78	1.70	314.60	356.29
Ranxe Bruz-Zall	1626.26	20.45	314.60	1249.95
Bruz Mal	1422.95	22.99	319.82	1623.64
Mner i Siperm	967.41	16.86	314.60	1180.65
Vilez	2343.93	20.00	321.57	1520.81
Zall Bastar	1979.42	18.11	335.58	1606.49
Total	**9515.24**			

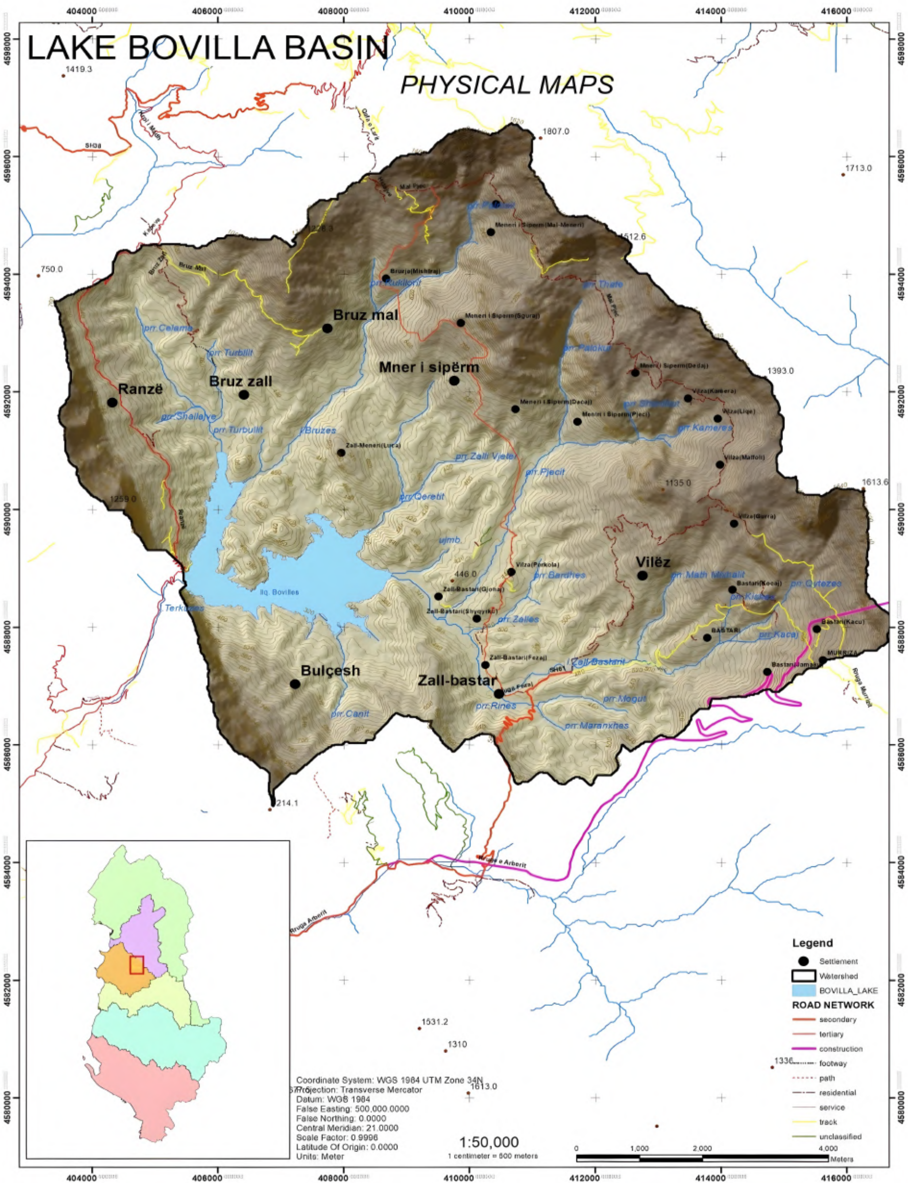

Figure 1. Location and physical map of the Bovilla watershed.

The Bovilla watershed is part of the Dajti National Park according to the Decision of the Council of Ministers No. 402 of 21 June 2006. The dam of the Bovilla reservoir has a height of 91 m as well as a length of 130 m and an elevation of about 321 m above sea level (a.s.l.) and is in the mouth of the Terkuza river. The climate is typical of the Mediterranean with relatively cold and wet winters and warm and dry summers. The area has a wide altitudinal range, directly affecting the climate variability. The mean annual temperature is 13.9 °C, the rainfall is 1718.6 mm/year, and the potential evaporation is 916 mm. Rainfall data are characterized by a non-uniform monthly distribution, where most of the precipitation falls during the autumn and winter months, being the main source of water supply for the hydrologic network in the Bovilla watershed.

Each watershed has its own runoff pattern and erosion rate which depends on the (i) geology, (ii) vegetation, (iii) land use, and (iv) topography. According to erodibility, the rocks of the Bovilla watershed can be classified as (i) high-eroded rocks (Quaternary deposits, 6.8 km^2 or 7% of the watershed), (ii) medium-eroded rocks (Flysch and Molasse, 70.2 km^2 or 71.6% of the watershed), and (iii) low-eroded rocks (Limestone and Dolomite, 21 km^2 or 22% of the watershed). The area is characterized by a strongly variable terrain with alternating mountainous, hilly, and flat areas. Based on the watershed DEM, around

80% of the Bovilla watershed has a slope from 15 to 30 degrees. The elevation of the Bovilla watershed varies from 300 to 1800 m a.s.l., and 80% of the watershed area has an altitude from 300 to 1000 m a.s.l. Some pedological properties of the main soils are provided in Table 3.

Table 3. Chemical composition of soils in the study area.

Sample Code	Soil Type	Laboratory Analysis							
		pH H_2O	pH $CaCl_2$	K Available	P Available	Organic Matter (%)	Sand	Silt	Clay
				mg/100 g				%	
M1B	Leptosol	8.16	7.38	9.50	0.12	1.28	15.76	49.90	32.10
ZB1A	Kambisol	7.60	6.95	22.80	1.01	5.06	12.46	65.66	21.89
ZB3F	Leptosol	8.16	7.39	14.50	0.30	5.39	16.42	52.79	30.79
ZB3P	Kambisol	6.66	5.86	13.10	0.25	1.93	18.80	52.91	28.90
ZB4O	Kambisol	7.42	6.90	21.90	3.74	5.26	16.70	51.65	27.43
M1F	Phaeozem	7.76	7.07	11.60	0.07	2.27	21.17	51.86	26.97
M2P	Kambisol	7.83	7.06	10.50	0.16	2.57	16.03	48.61	35.35
M2F	Kambisol	8.13	7.39	80.95	1.26	2.27	19.21	49.22	33.30

According to their texture, the soils studied can be divided into two broad soil groups, namely light silty soils (5 out of the 8 studied soils were silt loam) and medium soils (3 out of the 8 studied soils were silty clay loam). In general, the soils of the first group have comparably low organic matter contents and low aggregate stability. Therefore, these soils have a high risk of erosion where runoff occurs. The soils of the second group have a high content of silt and consequently are not as stable. They are susceptible to erosion, as the content of organic matter is low.

The main land use classes identified in the study area were (i) broadleaved forests, (ii) riparian vegetation along rivers and water streams, (iii) agriculture land, and (iv) pastures. Besides the identification of vegetation cover, we have estimated the respective area for each land use class within the Bovilla watershed (Table 4) and carried out their mapping by means of ArcGis software, version 9.5 (Figure A1). Based on the site conditions identified within the Bovilla watershed, we argue that the study area is particularly sensitive to soil erosion due to deforestation in the high-elevation areas and the presence of sparse vegetation areas.

Table 4. Land use classes in Bovilla watershed.

Land Use Classes (Corine Land Cover 2012)	Area (ha)
Pasture	302.531
Complex cultivated areas	453.654
Lands covered with crops and natural vegetation	1247.31
Broadleaved forests	2423.62
Conifer forests	149.153
Mixed forests	33.012
Herbaceous vegetation	517.519
Sclerophyll vegetation	1143.24
Transition areas from forests to shrub lands	1964.31
Others	130.525
Bare lands	0.00
Sparse vegetation areas	656.366
Aquatic areas (rivers, streams, lakes)	436.144
Total area	**9457.384**

In the previous study [44], areas with a high erosion risk (hotspot areas) were determined using the Revised Universal Soil Loss Equation (RUSLE) and GIS.

2.2. Determination of Soil Loss

Sedimentation in the Bovilla reservoir has caused many problems with water quality, a decrease in storage capacity, and water supply for the population as a result of turbidity rising. In order to update the data on soil loss at the Bovilla watershed, we started from a previous work [44] by using the same methodology. In that previous work, the sub-watersheds Ranxe, Vilez, and Zall-Bastar were selected as critical erosion areas, which contribute to about 65% of the sediment yield of the watershed, and in these critical areas, it is necessary to apply PESs programs [44].

Then, 25 experimental sample plots with regular and irregular shapes, located in the villages of Zall Bastar and Mner Sperm, were installed near the closing section of the selected sub-basins to monitor the soil loss caused by water erosion (weight of the soil derived from an area ranging from 65 to 100 m^2). The land use (forest, pasture, agricultural, bare lands, degraded forest land, and orchard) and the slopes (0–20%, 21–40%, 41–60%, and >60%) were the criteria to locate the hotspot areas for soil erosion. A mixture of all sediments collected during monitoring during the two-year test was examined in the laboratory, determining the exact weight of the sediments.

Each experimental erosion plot was coded in the field, and then, respective information regarding the geographic position, elevation, land use, slope, and exposure was recorded. For the coding of sample plots, the following rule was used: e.g., ZB1F/M1F, where the first letter(s) denotes the village name—Zall Bastar (ZB) or Mner (M); the number denotes the sample plot number; and the last letter (F) denotes the land use, such as "forest (F)". The area of each experimental sample plot was measured by means of a highly accurate Trimble GPS device. This information is summarized in Table A1. The authors of this research [44] elaborated on these data for the period from June 2017 to May 2018, while we update the study to September 2019. The map of the spatial distribution of soil erosion for the period June 2017–May 2018 [44] is reported in Figure A1 and clearly demonstrates that soil loss of less than 2.46 t/ha/year (tolerable soil loss in EU countries) covers only 96% of the study area, and the rest is dominated by higher erosion values (over 2.46 t/ha).

2.3. Identification of Ecosystem Services Correlated to Soil Erosion

We selected five ecosystem services linked to soil loss: the loss of carbon (regulating services), loss of mineral elements (K and P—supporting functions), habitat quality (supporting functions), crop productivity (provisioning services), and sustainable tourism suitability (cultural ecosystem services) (Figure 2).

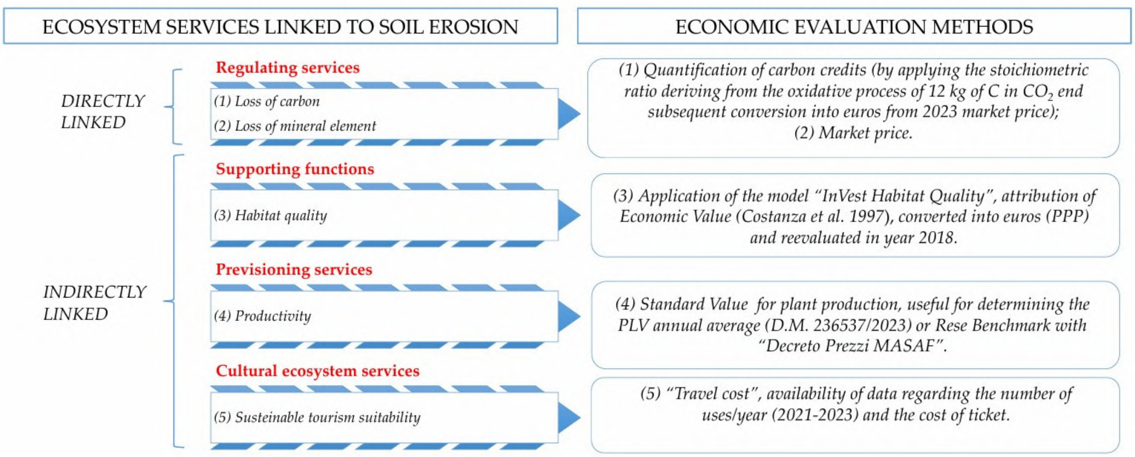

Figure 2. Economic evaluation methods of ecosystem services (authors' elaboration of [42–44]).

2.4. Application of Monetary Evaluation for Ecosystem Services Linked to Erosion

The economic evaluation of the ecosystem services was standardized in European currency (EUR); the value of each ecosystem service was estimated for each single plot and then summed. The soil quality was monitored with respect to K, P, and organic matter. For each plot, soil samples were collected and sent to the laboratory to analyze each parameter using the standard methods reported in Table A2. These data were used to quantify the monetary value of the loss of carbon and loss of mineral elements. The five ecosystem services and the related estimation methods are described as follows:

- *Loss of carbon (regulating services)*: The starting data are represented by the values expressed in average t/year (three-year period 2017–2019) of sediment loss due to the erosive process. Starting from these data, it was possible to quantify the percentage of organic substances [46] and therefore the content in kg of organic matter/ha. The transition from kg of organic matter per kg of carbon was carried out using the value of 58% (application of the inverse formula of the Van Bemmelen factor = 1.74). The transformation of C (kg) into CO_2 was carried out with the application of the stoichiometric ratio resulting from the oxidative process of 12 kg of carbon, therefore equal to 3.66 (12 kg of C + 32 kg of O_2 = 44 kg of CO_2). For the conversion into EUR, the prices (EUR/t CO_2) [47] for the year 2023 were used and compared with the average data for 2023 for the last 52 weeks [48] = 60.86 + 98.43 (average 79.45 EUR/t CO_2).
- *Loss of mineral elements (K and P—supporting functions)*: The content of K and P was evaluated from an economic point of view using the prices of mineral fertilizers (monopotassium phosphate and potassium nitrate), which contain a higher content of K and P, respectively. Starting from the values expressed in average t/year (three-year period, 2017–2019) of sediment loss due to the erosive process, the potassium and phosphorus contents were calculated (obtained from laboratory analyses for the 25 plots using the Mehlich 3-Extrable Elements Soil Analysis method), expressed in mg/100 g of analyzed soil, subsequently converted into kg/ha. The result expressed in kg was multiplied by the average trading values (EUR), obtained from market analyses relating to monopotassium phosphate and potassium nitrate. The indicative amount is around 3–4 EUR/kg. It should be noted that this study estimates the loss of P and K by analyzing the soil and not the sediment. It is known that there is usually an enrichment of nutrients in the sediments compared to the soils (sediment enrichment). Therefore, in this study, there is an underestimation of the concentrations of P and K and, therefore, of the performance in terms of the loss of the specific ecosystem service.
- *Economic assessment of habitat quality (supporting functions)*: In this study, the habitats present in the basin were evaluated in terms of "habitat quality", and a monetary value was subsequently attributed to them. "Habitat quality" was assessed using the Invest software (version 3.14.2), developed by the University of Stanford—Natural Capital Project [49]. The Invest software considers "habitat quality" as the ability of the ecosystem to provide conditions appropriate for individual and population persistence, and it is considered a continuous variable in the model, ranging from low to medium to high, based on the resources available for survival, reproduction, and population persistence, respectively [50]. Habitats with a high quality are relatively intact and have a structure and function within the range of historic variability. "Habitat quality" depends on a habitat's proximity to human land uses and the intensity of these land uses. Generally, "habitat quality" is degraded as the intensity of nearby land use increases [51–53]. The model runs using raster data, where each cell in the raster is assigned a Land Use Land Cover (LULC) class, which can be a natural (unmanaged) class or a managed class. LULC types can be given at any level of classification detail. Besides a map of LULC and data that relate LULC to habitat suitability, the model also requires data on the habitat threat density and its effects on habitat quality. In general, we consider threats to be human-modified LULC types that cause habitat fragmentation, edge, and degradation in neighboring habitats. The following inputs were used for the case study: (i) the land use map (current landcover map) and (ii) the threat maps. All maps used in the Invest software have a cell size of 20 m. The characteristics of "habitat" or "no-habitat" were attributed to each LULC type. As regards the threats, this study considered the presence of roads, the presence of

crops and agricultural activities, the presence of urbanized areas, and the proximity to contexts affected by erosion.

- The result of the processing is a habitat quality map in which each cell is given a score ranging from 0 (low HQ) to 1 (high HQ). The input maps and the resulting "habitat quality map" are shown in the following figures (Figures 3 and A2–A6). The HQ values obtained (range 0–1) were then multiplied by the economic value given by the authors of [54] which assigns an economic amount to each area with different land use. The assigned value, expressed in 2007 USD/ha/year, was converted into EUR 2018 (intermediate year of this work) through the purchasing power parities (PPPs) [55], subsequently adjusted to 2018 by consulting the data available from the Italian Statistics Institute [56].
- *Crop productivity (provisioning services)*: The economic value of the agricultural production obtainable from the plots under investigation was quantified through the application of the Italian Ministerial Decree no. 236,537 of 5 May 2023 that established the identification of the standard values for plant production to determine the value of the average annual production and the maximum values that can be insurable on the subsidized market and to join mutual funds (EUR/ha). For forestry crops, however, the formula 0.5*d2*H (Bouvard formula) was applied. The diameters, heights, and number of plants per hectare divided by age were reported in the Bovilla database simple plot—forest info (not published). The total volume (q/ha) was multiplied by 6 EUR/q (for coniferous trees) and by 14 EUR/q (for broadleaved trees, average purchase and sale value of coniferous and broadleaved forests expressed in EUR).

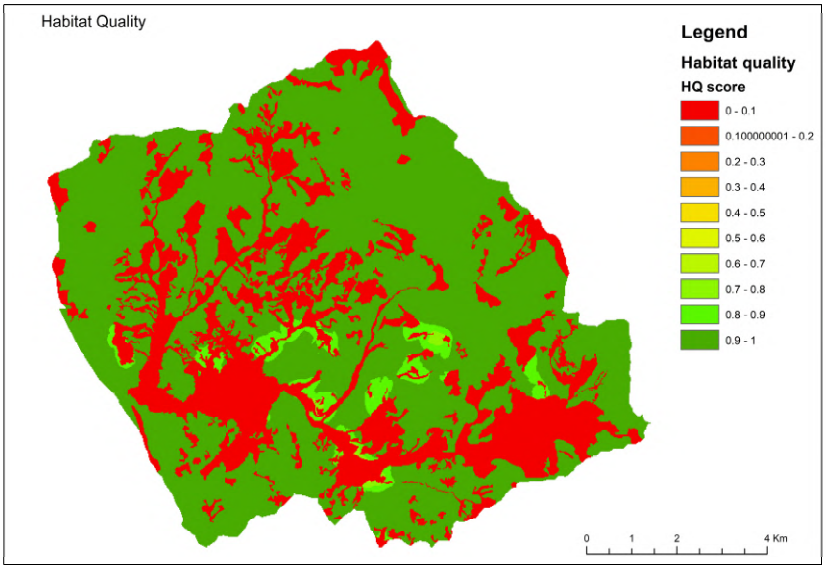

Figure 3. Habitat quality.

- *Sustainable tourism suitability (cultural ecosystem services)*: For the evaluation of this ecosystem service, we considered the "sustainable tourism suitability" (STS) defined as the potential of the territory to offer services for sustainable tourism. To estimate the performance of this service within the park territory, we started from the following assumption: a territory, or parts of it, can have a performance in terms of tourism suitability depending on the presence or absence of some territorial elements: roads, hiking trails, habitat/naturalistic areas, restaurants, bar, hotels, sports facilities, and historical–cultural elements. A total of 4 macro-groups of territorial elements were defined and are shown in Table 5.

Table 5. Methods and standards used for chemical compound analysis.

Territorial Element	Description
Road network	All roads in the park
Network of paths	The network of pedestrian roads and hiking trails
Habitat quality	The spatial distribution of elements with high naturalistic value within the park
Points of interest	Restaurants, bars, hotels, sports facilities, and historical–cultural elements

- To evaluate the spatial distribution of the ecosystem service, we then proceeded to evaluate the spatial distribution of each characteristic by carrying out a density analysis in a GIS environment. The density map of each feature was normalized (Figures A7–A10). An overlay analysis was then performed to obtain a performance map of STS for which each cell (cell size of 20 m) was attributed with a value within the range of 0–4 (low–high STS) as a result of the sum of the spatial density values of the individual territorial elements (Figure 4).

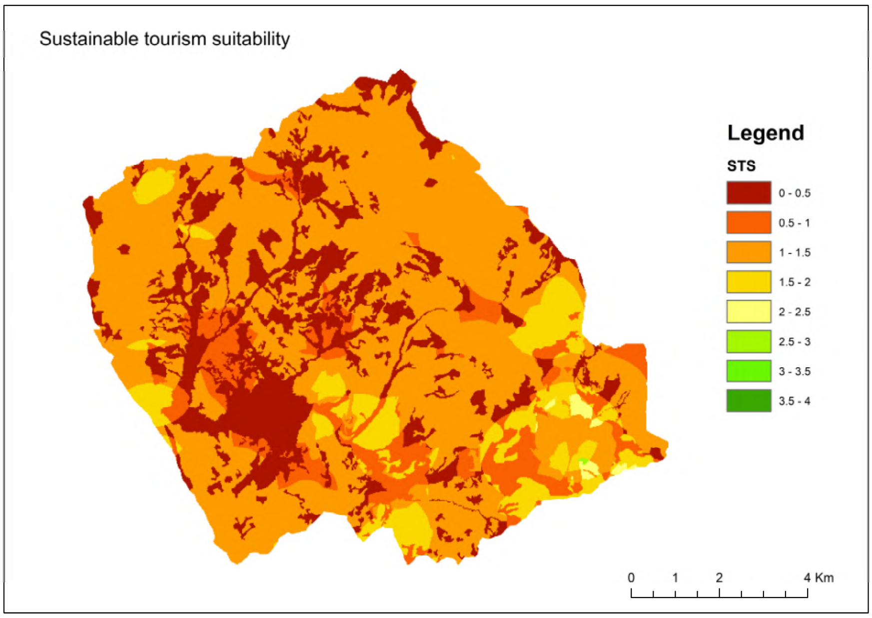

Figure 4. Sustainable tourism suitability (STS, score range 0–4 = road network density map score range 0–1 + network of paths density map score range 0–1 + habitat quality map score range 0–1 + point of interest density map score range 0–1).

- The values of direct tourist flows within the "Parku Kombetar Mali i Dajtit" National Park provided by the National Agency for Protected Areas were used. The average annual flow (three-year period, 2021–2023) was 126,057 units that used the cableway to reach the protected area (within which the Bovilla Basin lies), departing from the city of Tirana. Official investigations show that the price of the cableway ticket is around 2 EUR/each. Therefore, the economic value in terms of tourist attractiveness of the entire protected area, considering only the value of the public transport ticket, is equal to 252,115 EUR/year. The extent of the entire protected area is 29,193.27 ha; thus, each single area can be standardized to the value of EUR 8.63.

2.5. Application of the Replacement Cost Method

We used the replacement cost method to transform bare ground, orchards, and pastures into forest soil to compare the result with the total value of the previous five ecosystem services. The transformation value (i.e., the replacement cost) of the agricultural land, pastures, and bare land under investigation was economically compared with the creation of an initial afforestation plant. The determination of the transformation value (EUR/ha) was obtained with two different methods. First, the economic values of the transformation of agricultural land into forestation interventions were used, in compliance with the Rural Development Programme (RDP) of the Puglia Region, which is the main funding instrument within the European Agricultural Fund for Rural Development (FEASR) through which the Puglia regional government promotes key interventions for the development of rural areas. Subsequently, the second method was adopted by applying the unit values (EUR/ha) of the cost items taken from the price list of the Puglia Region, attached to the Decision of the Regional Council (DGR) LLP/DEL/2023/00012. In both methods, the economic values of income loss and the maintenance values of the forestation systems were added to the values obtained, multiplied by 12 years (see the notice of the first afforestation of agricultural land—Measure 8.1 of the RDP of Puglia Region 2014–2020) [57].

3. Results

3.1. Determination of Soil Loss

The amount of soil loss for the whole monitoring period was 2705.6 t/ha, while the mean soil loss at the sample plot level was 108.22 t. The soil loss varied between land use and years (Table 6).

Table 6. Sum of soil loss (t/ha) by land use and year.

Land Use	Total Soil Loss by Year (t/ha)		
	2017	2018	2019
Agricultural land	57.59	90.37	29.05
Bare land	773.78	747.47	283.61
Degraded forest	25.27	35.24	11.53
Forest	33.13	63.03	26.20
Orchard	81.63	79.30	19.36
Pasture	154.81	136.09	58.15
Total	**1126.21**	**1151.50**	**427.90**

The mean soil loss varied between land use categories. Over the monitoring period, the lowest values of soil loss measured in forest lands ranged from 5.24 t/ha (2019) to 12.61 t/ha (2018), while the maximum values were reached in bare lands, from 56.72 t/ha (2019) to 154.76 t/ha (2017) (Table 7).

Table 7. Mean soil loss (t/ha) by land use and year.

Land Use	Mean Soil Loss by Year (t/ha)			Mean Soil Loss (2017–2019) t/ha
	2017	2018	2019	
Agricultural land	19.20	30.12	9.68	19.67
Bare land	154.76	149.49	56.72	120.32
Degraded forest	25.27	35.24	11.53	24.01
Forest	6.63	12.61	5.24	8.16
Orchard	40.82	39.65	9.68	30.05
Pasture	17.20	15.12	6.46	12.93
Total	**45.04**	**46.06**	**17.12**	**36.07**

On average, the mean soil loss over the monitoring period (2017–2019) was 36.07 t/ha, ranging from 8.16 t/ha (forest) to 120.32 t/ha (bare land). We noticed that the soil loss per 1 hectare varied between sample plots, and the largest values were reached in 2019 (Figure 5). As expected, different amounts of runoff and sediment were generated from soils with different land use statuses. The trend of soil loss was as follows: bare land > orchard > degraded forest > agricultural land > pasture > forest. The soil loss varied between land uses from 8.16 t/ha in forest lands to 120.32 t/ha in bare lands. The soil loss proportionally increased when the slope rose from 20% to more than 61%.

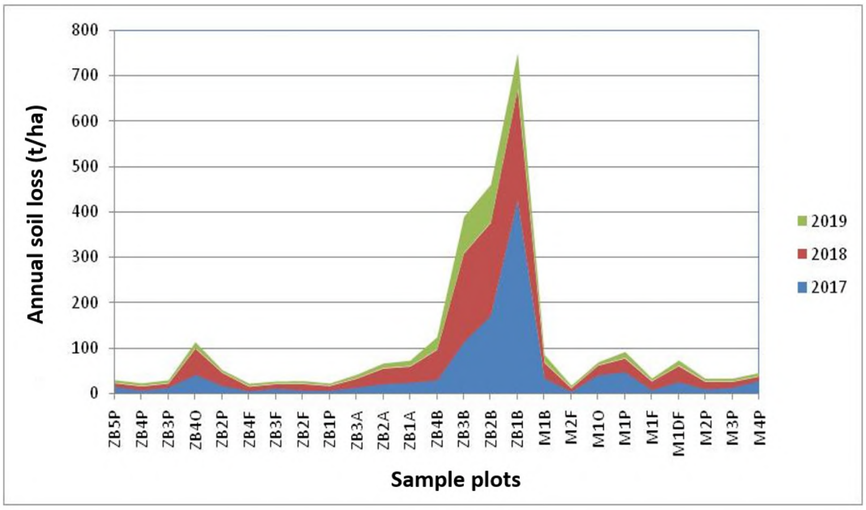

Figure 5. Soil loss (t/ha) by sample plots over the monitoring period.

3.2. Use of Monetary Methods for the Evaluation of Ecosystem Services Linked to Erosion

The value of the five analyzed ecosystem services (loss of carbon, loss of mineral elements K and P, habitat quality, crop production, and cultural ecosystem services) is reported in Table A3. From the obtained results, we observed the following:

- The economic value of carbon loss (CO_2/ha) varies from 0.01 to 348,94.00 EUR/t;
- The economic value of the loss of chemical elements varies from 0 to 1641.19 EUR/ha for K and from 0 to 224.22 EUR/ha for P;
- The economic value of the habitats varies from 0 to approximately 5000.00 EUR/ha;
- The economic value of crop production varies from 0 to 35,320.50 EUR/ha; thus, the economic weight/ha of this service is more incisive than that of the previous ones.

4. Discussion

4.1. Replacement Cost

The value of the calculated replacement cost is reported in Table A4. The value of the restoration cost granted by the Puglia Region (estimated only for agricultural land, meadows, and pastures) is around 10,500.00 EUR/ha considering the contribution values provided by the Rural Development Program [57], while it is around EUR 18,192.00 if the estimate is made only with data from the Puglia Region price list for the year 2023 [58]. The already existing forests were not investigated.

4.2. Comparison

Comparing the economic values of restoration (afforestation) with the data derived from the application of the cost–benefit analysis, the following key points emerge:

1. It is always economically convenient to change the intended use of the land from pasture to forest (where possible and not in conflict with current environmental legislation), from agricultural land (corn or fodder) to forest, and from bare land to forest (where possible and not in conflict with current legislation). There is economic convenience if the values derived from the cost–benefit analysis are compared with the economic values of replacement cost from the Puglia Region price list (Table A5, value “Replacement cost”), while there is not economic convenience if the replacement cost values derive from the application of Measure 8.1 of the Rural Development Program of the Puglia Region [57].

2. It is possible to compare the values described above for a period of 12 years (minimum period to allow a forestry seedbed to become young and stable, to grant the economic prize for forest maintenance and compensate the loss of income from the previous crop within the RDP of Puglia Region). Also, in this case, the considerations of convenience reported in point 1 are confirmed.
3. It is more convenient from an economic point of view to transform bare land or pasture to forest (where in compliance with the legislation), since the bare land and pastures are almost non-productive. It is less convenient if the conversion takes place from productive agricultural land, even simply arable land (Table A5, value "Economic Convenience EUR/ha"), because the value of the ecosystem service of production (supply of products) is calculated with the MASAF 2023 Standard Value [59].
4. It is also underlined that for the ZB4O orchard, for the M1O orchard, and for the ZB2A arable land, the convenience of carrying out the intervention is uneconomical even considering the replacement cost values and the values of ordinary maintenance that are higher than the price list of the Puglia Region (Table A5).
5. It is not economically convenient to transform highly productive land (vineyards, plum orchards, horticultural crops, etc.), which is characterized by ecosystem services of very high economic value and not appropriately compensated by the replacement costs, maintenance prize, and income loss. The maintenance prize should be raised from EUR 2846.00 to at least EUR 7566.20 [57], as described in Table A5 (column "Total cost"). This is due to more frequent extreme weather events that drastically reduce the rooting of new plants, especially in the summer period, with the need to carry out at least six irrigations per year.

5. Conclusions

This research updated the previous data on soil loss at the Bovilla watershed to September 2019 and focused on the identification and monetary evaluation of the ecosystem services (ESs) linked to soil erosion. Agriculture is a key driver of soil erosion and soil contamination by fertilizers. The presence of soil erosion in the Bovilla watershed caused by agriculture is closely related to farming practices (land ploughing, irrigation, crop rotations, crop management, etc.), which might be considered as indicators of pressures on watershed erosion. Therefore, agriculture management should be monitored in the Bovilla watershed as an important factor influencing soil erosion; measures should be implemented to find suitable remedial measures and encourage farmers to adopt soil conservation techniques.

The evaluation of the on-site and off-site impacts of soil erosion is closely related to the pedoclimatic characteristics and land uses. This evaluation is not only difficult but also expensive, and specific data are often not available. Indeed, to overcome the lack of data, the evaluation of the ecosystem services was performed by gathering data from official documents of the Rural Development Programme of Puglia Region (Southern Italy) and from the Italian Institute of Statistics. This was conducted because Puglia and some areas of Albania have similar pedoclimatic conditions and land uses. Therefore, future research should be focused on collecting data directly from the Bovilla watershed.

Land use and management result from human activities, and they are the most important factors that influence and control accelerated soil erosion. Land cover, especially for forest land, has been altered to degraded forest land, affecting the erosion rates in the Bovilla watershed. The main factors in land cover change in the study area are illegal logging and forest fires. Therefore, the promotion of funding schemes in the framework of payments for ecosystem services is essential to support activities including reforestation, regeneration, dam construction, and so on.

The economic consequences of soil erosion in the Bovilla watershed are multifold. The loss of topsoil is associated with a reduction in soil productivity associated with a reduction in arable crop yield (e.g., wheat and corn), forage, orchards, and vineyards, which are crucial to ensure the food security of the local population.

For the specific conditions of Albanian forests, their management should be focused on the principles of sustainable mountain development. In this way, two different goals can be pursued: (1) to improve the natural capital and quality of life of upland populations and (2) to ensure ecosystem stability also in the urbanized territories downstream of the watershed basin. This means a greater involvement of local populations in planning and implementing management strategies and programs, often with more direct benefits to mountain populations.

Broadleaved forests, coniferous forests, and herbaceous vegetation provide good-quality fresh water. To increase the water quality parameters in the Bovilla watershed, it is crucial to enhance the green surface, promote reforestation, and protect soil from erosion. We are aware that the correct use of land cannot be linked exclusively to forestation or reforestation interventions and should be guaranteed by the adoption of sustainable agronomic techniques for food production [60].

Nevertheless, national and international policies aimed at the maintenance and expansion of habitats and natural territories to the detriment of agriculture, especially in areas with intensive agriculture, should make a better allocation of resources in future programming, rewarding as a priority, and with much greater contributions to current, the execution of afforestation works, especially in terms of compensation for income loss from previous crops.

Overall, this research highlighted that the combination of the monetary assessment of ESs linked to soil erosion and mapping on a spatial scale can help decision-makers to develop sustainable territorial planning and policies; quantifying the value of ESs could become fundamentally important in the decision-making processes related to land use.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author (the data are not publicly available due to privacy).

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. General information about the sample plots in Bovilla watershed.

No.	Sample Plot Code	Location		Elevation a.s.l (m)	Slope		Area (m^2)	Soil Type
		N	E		Degree	%		
1	ZB1A	N 41°26′31.71″	E 19°54′55.79″	325	2.8	5	69.3	Fluvic Kambisols
2	ZB2A	N 41°26′34.71″	E 19°54′57.47″	327.6	2.5	4.6	89.5	Fluvic Kambisols
3	ZB3A	N 41°26′38.18″	E 19°54′53″	321.5	7	13.2	145.3	Regosols Eutric
4	ZB1F	N 41°26′42.45″	E 19°54′51.23″	329	18.4	34.6	72.9	Haplic Kambisol
5	ZB1B	N 41°26′41.57″	E 19°54′59.25″	357	31.8	62	42.5	Haplic Leptosols
6	ZB2B	N 41°26′38.50″	E 19°55′01.79″	358	35.7	72	46	Haplic Leptosols
7	ZB3B	N 41°26′38.76″	E 19°55′01.91″	360	36.5	74	41.9	Haplic Leptosols
8	ZB3F	N 41°26′37.62″	E 19°55′03.04″	363	237	44	66.9	Haplic Leptosols
9	ZB4F	N 41°26′38.40″	E 19°55′01.79″	353	32.6	64	74.5	Haplic Kambisols
10	ZB4B	N 41°26′36.63″	E 19°55′02.05″	350	23.3	43	66.7	Haplic Leptosols
11	ZB2P	N 41°26′35.97″	E 19°54′58.94″	340	19.8	36	70	Kambisols Eutric

Table A1. *Cont.*

No.	Sample Plot Code	Location		Elevation a.s.l (m)	Slope		Area (m²)	Soil Type
		N	E		Degree	%		
12	ZB3P	N 41°26′36.97″	E 19°54′57.89″	336	13.6	24.2	85	Kambisols Eutric
13	ZB4P	N 41°26′36.23″	E 19°55′00.00″	341	19.8	36	65.6	Kambisols Eutric
14	ZB5P	N 41°26′36.64″	E 19°55′00.98″	346	7.4	13	85.5	Kambisols Eutric
15	ZB4O	N 41°26′37.52″	E 19°54′58.55″	342	15.8	28	72.3	Kambisols Eutric
16	ZB2F	N 41°26′35.70″	E 19°54′59.23″	337	31.8	62	59.3	Kambisols Eutric
17	M1O	N 41°27′45.42″	E 19°55′51.39″	491	20.2	41	74.9	Haplic Luvisols
18	M1P	N 41°27′44.86″	E 19°55′51.97″	474	29	55	19.4	Haplic Luvisols
19	M1F	N 41°27′47.20″	E 19°55′53.49″	473	21.6	40	63.6	Haplic Luvisols
20	M1DF	N 41°27′47.16″	E 19°55′54.35″	467	17.8	32	73.8	Kambisols Eutric
21	M2P	N 41°27′47.34″	E 19°55′52.22″	484	21.7	40	72.9	Haplic Luvisols
22	M1B	N 41°27′54.53″	E 19°55′47.63″	507.5	25.6	48	159.2	Kambisols Eutric
23	M2F	N 41°27′53.72″	E 19°55′46.83″	497	15.4	28	72.9	Haplic Leptosols
24	M3P	N 41°27′45.14″	E 19°55′53.18″	468	32.2	63	78.5	Kambisols Eutric
25	M4P	N 41°27′46.25″	E 19°55′54.15″	465	33.0	65	39.4	Haplic Luvisols

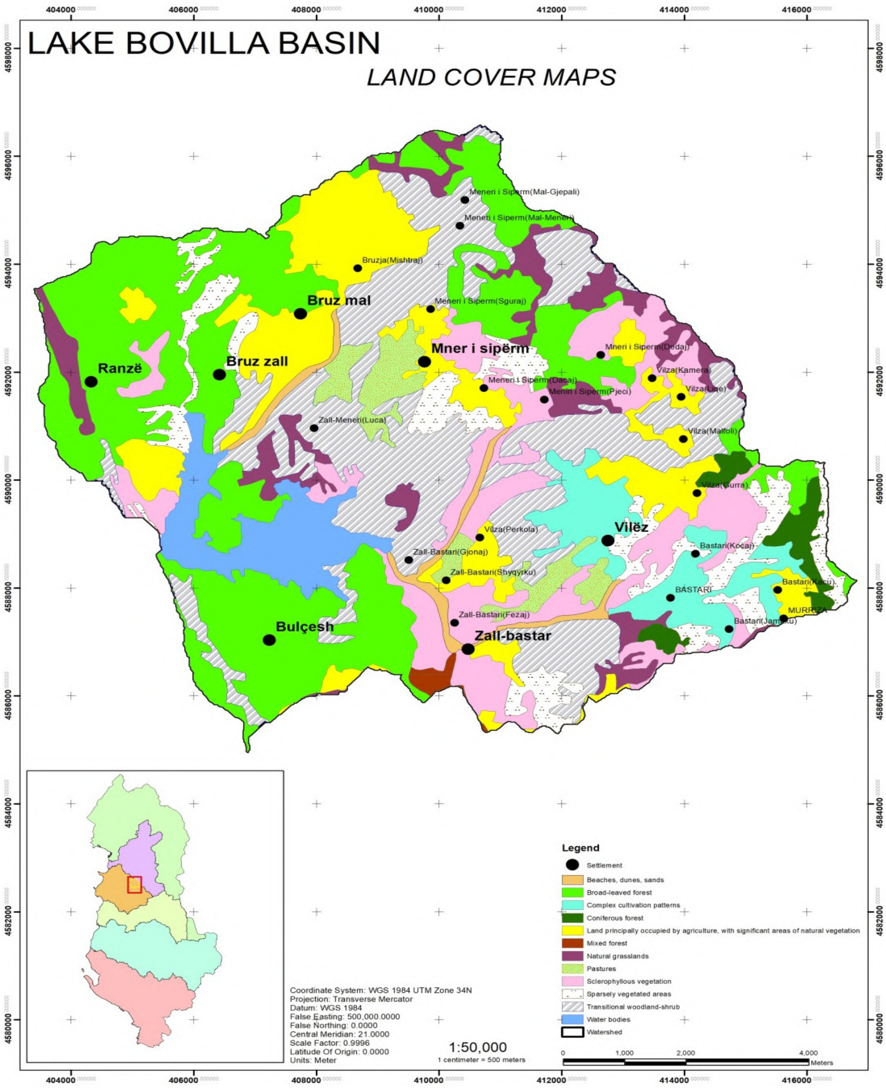

Figure A1. Land cover map of Bovilla watershed.

Table A2. Methods and standards used for chemical compound analysis.

Sample Plot Code	K (Mehlich 3-Extrable Elements Soil Analysis) (kg/ha)	P (Mehlich 3-Extrable Elements Soil Analysis) (kg/ha)	Organic Matter Converted into CO_2 [1] (kg/ha)
ZB5P	124.882	2.287	384.509
ZB4P	94.398	1.729	289.138
ZB3P	123.179	2.256	385.254
ZB4O	820.593	140.137	4183.873
ZB2P	222.307	4.072	688.056
ZB4F	100.963	2.088	768.651
ZB3F	122.960	2.544	11.441
ZB2F	117.022	2.143	4.075
ZB1P	101.732	2.104	10.868
ZB3A	−306.432	13.574	10.401
ZB2A	495.352	21.943	10.571
ZB1A	543.460	24.074	10.741
ZB4B	462.358	21.145	0.679
ZB3B	502.351	19.135	0.424
ZB2B	92.284	1.9473	0.382
ZB1B	94.874	3.997	0.148
M1B	267.073	3.373	2.717
M2F	7.009	7.009	4.818
M1O	295.57	4.965	7.854
M1P	317.65	4.840	3.545
M1F	125.81	0.759	4.818
M1DF	203.467	4.906	4.670
M2P	110.355	1.68	5.455
M3P	111.856	1.704	5.307
M4P	155.431	2.368	5.349

[1] Application of the inverse formula of the Van Bemmelen factor: organic C content equal to 58% of the weight of the organic substance; transition from organic C to CO_2 by applying the stoichiometric formula 12 kg of C + 32 kg of O_2 = 44 kg of CO_2, from which it can be deduced that the ratio between C and CO_2 is 3.66 (values expressed in kg, subsequently indicated as t for the purpose of a monetary evaluation).

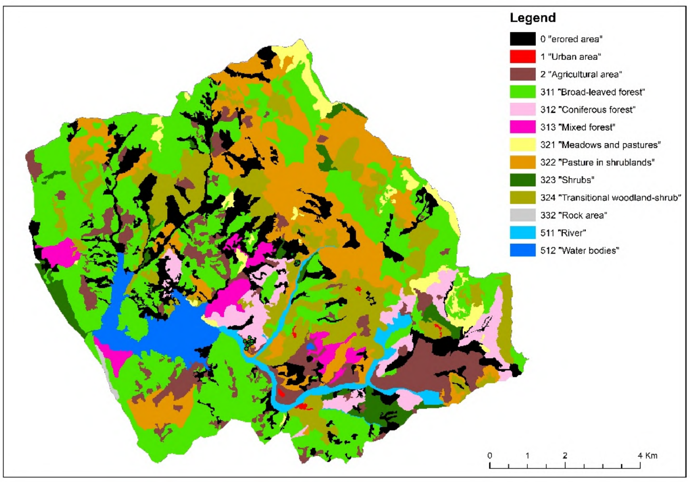

Figure A2. Land use.

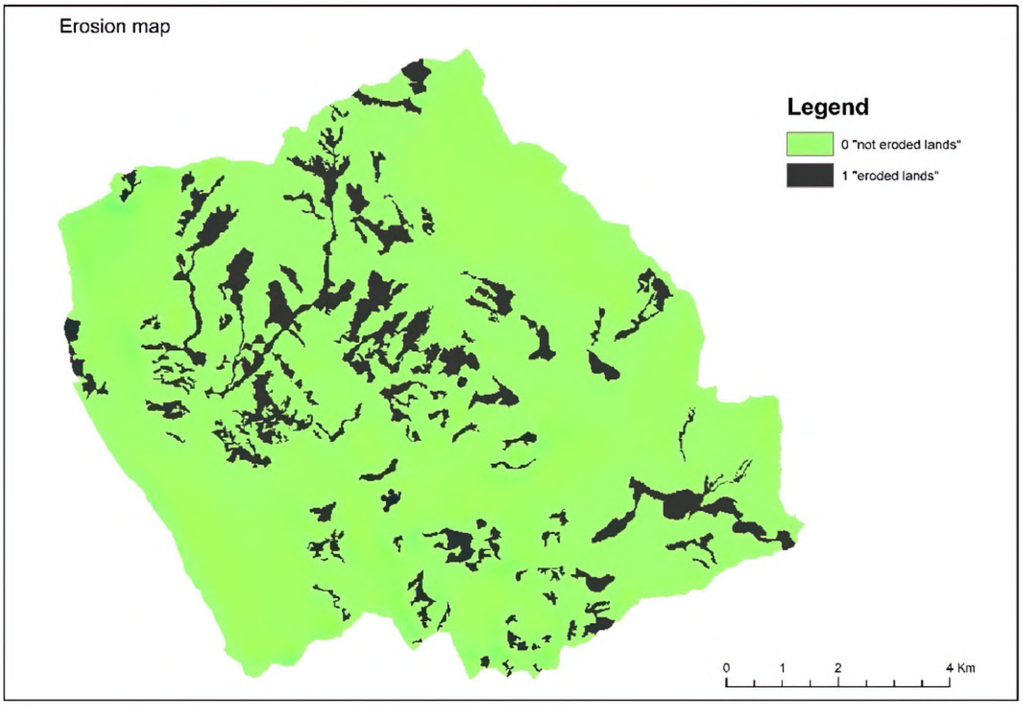

Figure A3. Erosion map.

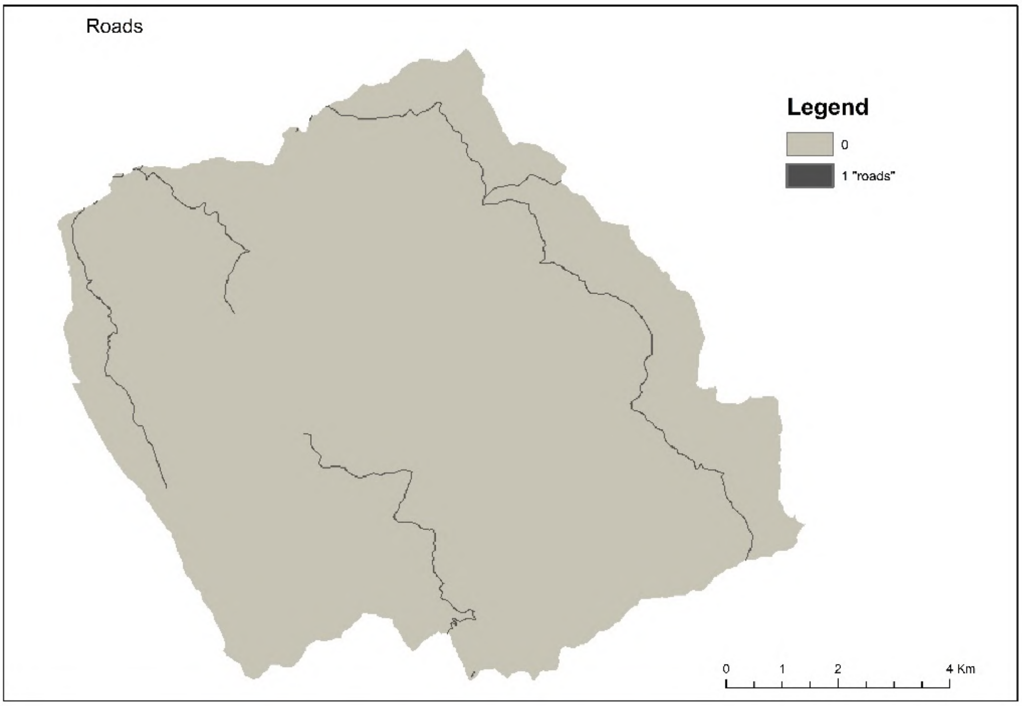

Figure A4. Roads.

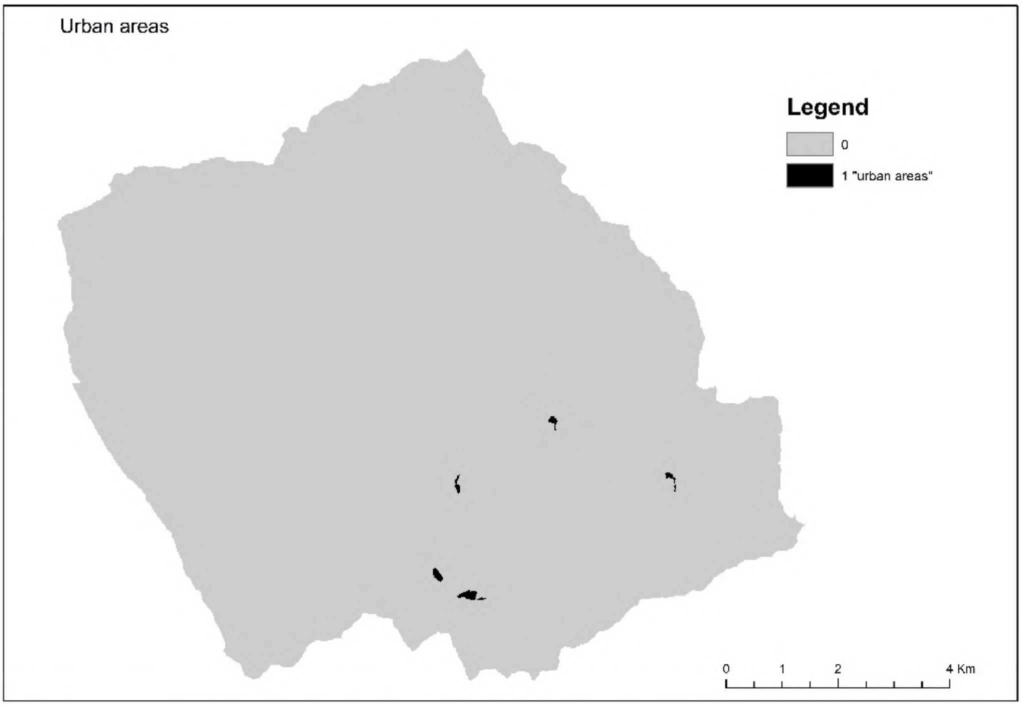

Figure A5. Urban areas.

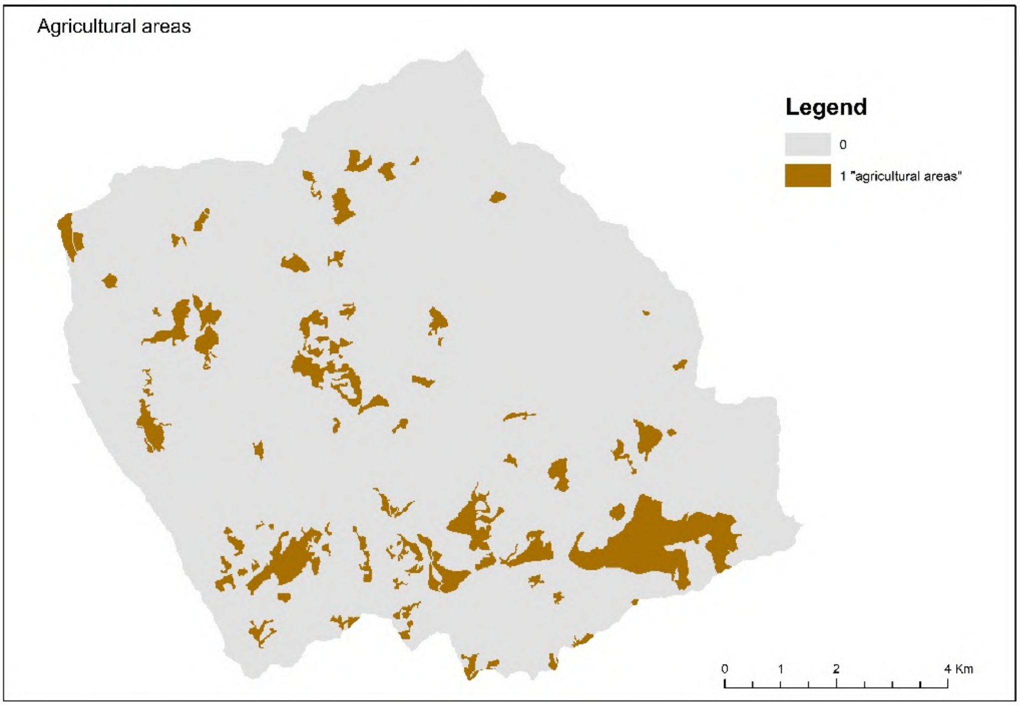

Figure A6. Agricultural areas.

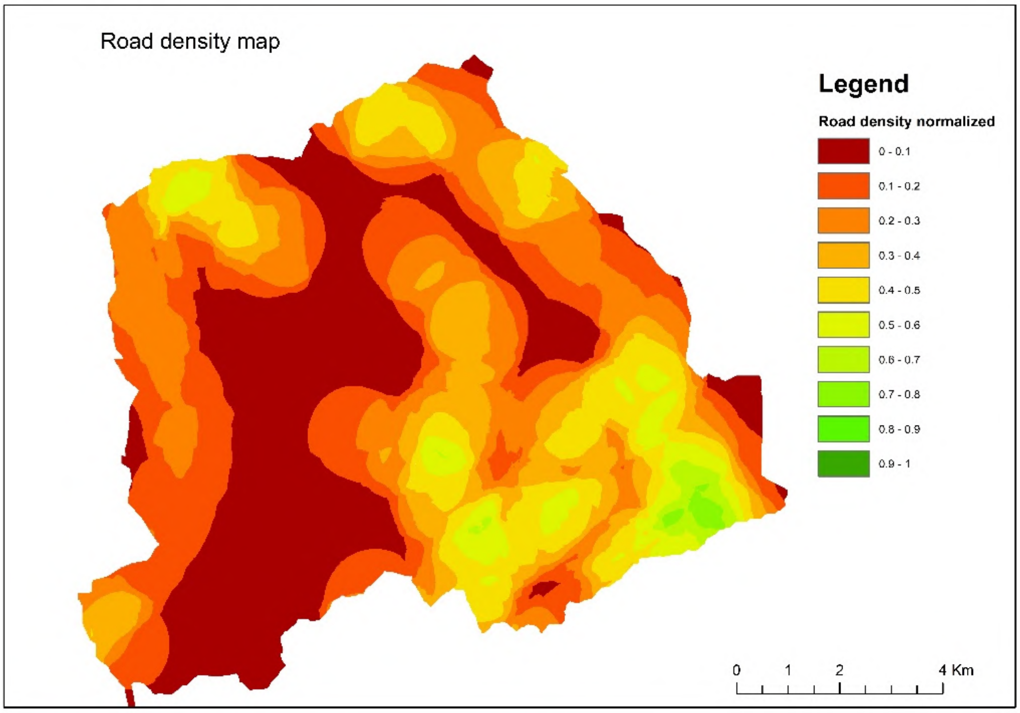

Figure A7. Road density map.

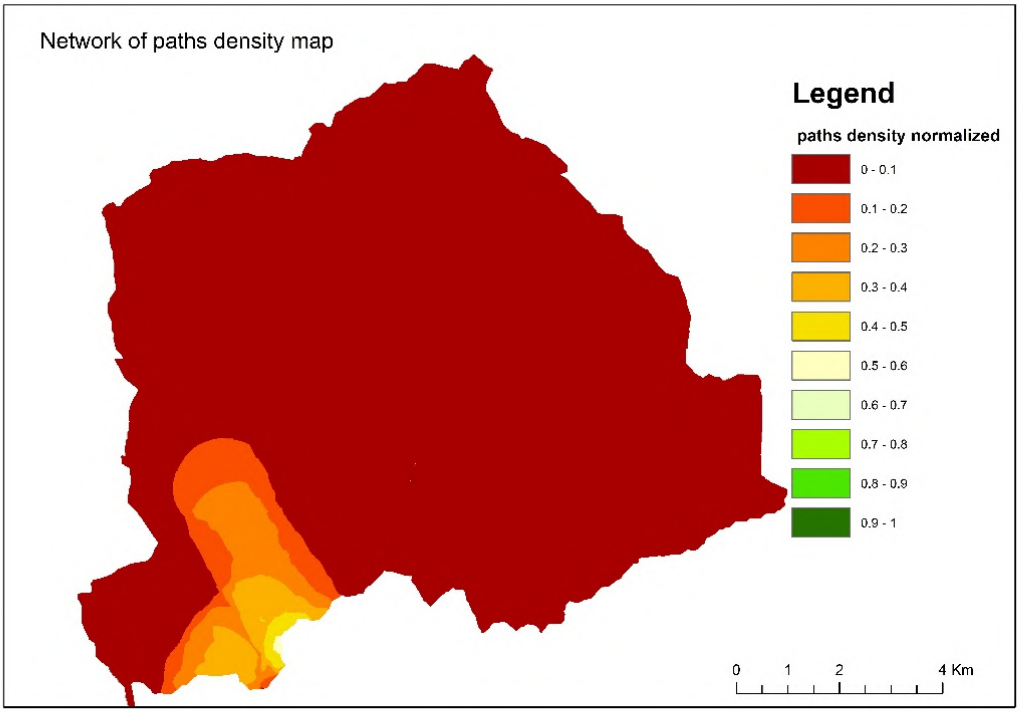

Figure A8. Network of paths density map.

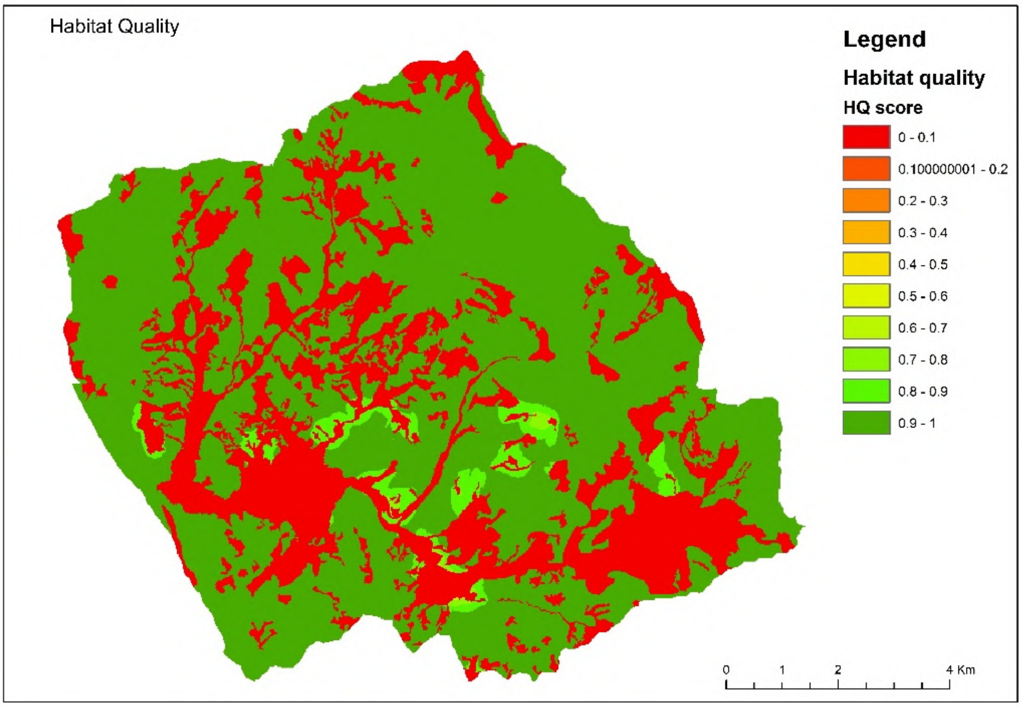

Figure A9. Habitat quality.

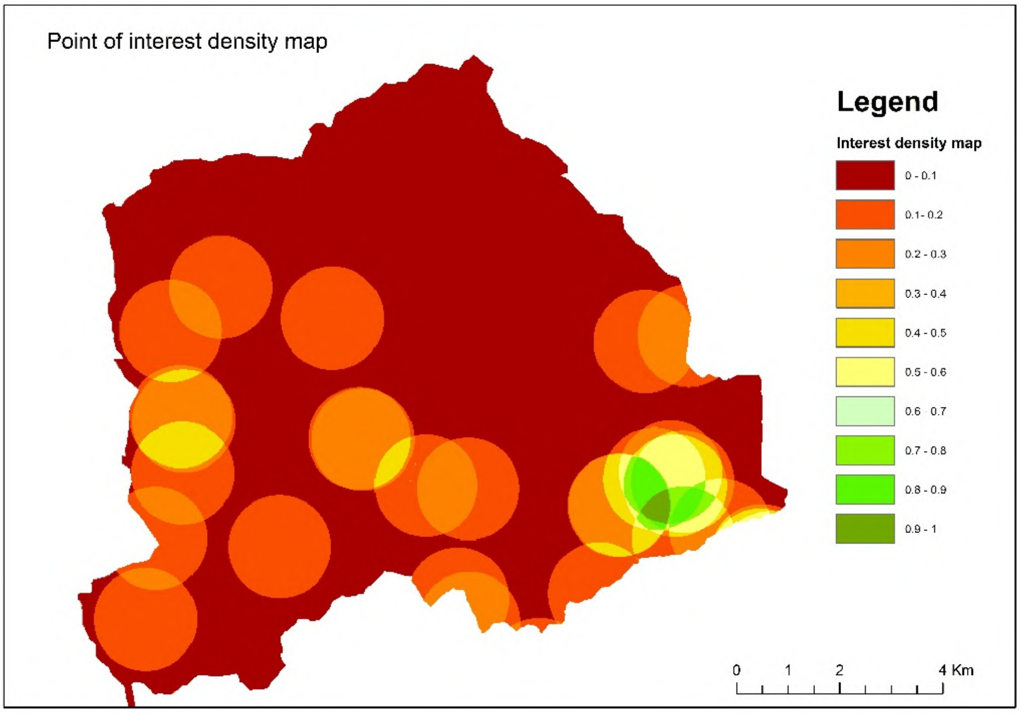

Figure A10. Point of interest density map.

Table A3. The value of the five ecosystem services investigated in the plots.

Sample Plot Code	Land Use Classes (Corine Land Cover 2012)	I (Regulating)	II (Regulating)	III (Provisioning)	IV (Supporting)		V (Cultural)
		CO_2 (EUR/t)	Habitat Quality (EUR/ha)	Agricultural and Forestry Production (EUR/ha)	K (EUR/ha)	P (EUR/ha)	CES (EUR/ha)
ZB5P	Pasture	32.07	2892.09	326.00	249.76	3.66	5.57
ZB4P	Pasture	24.11	2930.39	326.00	188.80	2.77	5.51
ZB3P	Pasture	32.13	2923.44	326.00	246.36	3.61	5.42
ZB4O	Orchard	348.94	0.00	35,320.50	1641.19	224.22	2.20
ZB2P	Pasture	57.38	2931.38	326.00	444.61	6.52	5.45
ZB4F	Conifer forests	64.11	0.00	2600.88	201.93	3.34	2.45
ZB3F	Conifer forests	0.95	2377.92	2600.88	245.92	4.07	6.00
ZB2F	Oak forest with pasture	0.34	2203.63	326.00	234.04	3.43	5.46
ZB1P	Conifer forests	0.91	2524.45	2701.08	203.46	3.37	6.39
ZB3A	Agricultural land (corn)	0.87	0.00	3948.00	612.86	21.72	3.11
ZB2A	Agricultural land (corn and beans)	0.88	0.00	5757.50	990.71	35.11	2.20
ZB1A	Forage	0.90	0.00	2086.00	1086.92	38.52	2.20
ZB4B	Bare lands	0.06	0.00	0.00	0.00	0.00	5.89
ZB3B	Bare lands	0.04	0.00	0.00	0.00	0.00	2.49
ZB2B	Bare lands	0.03	0.00	0.00	0.00	0.00	2.45
ZB1B	Bare lands	0.01	0.00	0.00	0.00	0.00	6.39
M1B	Bare earth with renaturalization	0.23	0.00	0.00	534.15	5.40	1.47
M2F	Broadleaved forests	0.40	0.00	1147.93	14.02	11.22	1.48
M1O	Orchard	0.66	5156.14	32,843.33	0.00	0.00	5.60
M1P	Cultivated meadow (alfalfa)	0.30	3867.06	2114.00	635.31	7.74	5.64
M1F	Broadleaved forests	0.40	2900.63	1147.93	251.63	1.21	5.67
M1DF	Degraded forest	0.39	2905.11	653.52	0.00	0.00	5.67
M2P	Cultivated meadow (alfalfa)	0.45	3840.83	2114.00	220.71	2.69	5.67
M3P	Pasture—meadow (alfalfa)	0.44	3863.92	770.00	223.71	2.73	5.60
M4P	Pasture—meadow (alfalfa)	0.45	3862.22	770.00	310.86	3.79	5.60

Table A4. Comparison between replacement cost values and authorized costs reported in the Rural Development Programme (RDP) of Puglia Region, with detail of the values of maintenance prize and income loss for each individual plot.

Sample Plot Code	Sub-Basin Name	Land Use Classes (Corine Land Cover 2012)	Replacement Cost (EUR/ha)	Authorized Costs (RDP Puglia) (EUR/ha)	Loss of Income (EUR/ha)	Loss of Income for 12 Years (EUR/ha)	Maintenance Prize for 12 Years (EUR/ha)	Total Cost [1] (EUR/ha)
ZB5P	Zall Bastar	Pasture	18,192.00	10,500.00	0.00	0.00	34,154.40	52,346.40
ZB4P	Zall Bastar	Pasture	18,192.00	10,500.00	0.00	0.00	34,154.40	52,346.40
ZB3P	Zall Bastar	Pasture	18,192.00	10,500.00	0.00	0.00	34,154.40	52,346.40
ZB4O	Zall Bastar	Orchard	18,192.00	10,500.00	950.00	11,400.00	34,154.40	63,746.40
ZB2P	Zall Bastar	Pasture	18,192.00	10,500.00	0.00	0.00	34,154.40	52,346.40
ZB4F	Zall Bastar	Conifer forests	0.00	0.00	0.00	0.00	0.00	0.00
ZB3F	Zall Bastar	Conifer forests	0.00	0.00	0.00	0.00	0.00	0.00
ZB2F	Zall Bastar	Oak forest with pasture	0.00	0.00	0.00	0.00	0.00	0.00
ZB1P	Zall Bastar	Conifer forests	0.00	0.00	0.00	0.00	0.00	0.00
ZB3A	Zall Bastar	Agricultural land (corn)	18,192.00	10,500.00	700.00	8400.00	34,154.40	60,746.40
ZB2A	Zall Bastar	Agricultural land (corn and beans)	18,192.00	10,500.00	700.00	8400.00	34,154.40	60,746.40
ZB1A	Zall Bastar	Forage	18,192.00	10,500.00	64.00	768.00	34,154.40	53,114.40
ZB4B	Zall Bastar	Bare lands	18,192.00	10,500.00	0.00	0.00	34,154.40	52,346.40
ZB3B	Zall Bastar	Bare lands	18,192.00	10,500.00	0.00	0.00	34,154.40	52,346.40
ZB2B	Zall Bastar	Bare lands	18,192.00	10,500.00	0.00	0.00	34,154.40	52,346.40
ZB1B	Zall Bastar	Bare lands	18,192.00	10,500.00	0.00	0.00	34,154.40	52,346.40
M1B	Mner i Siperm	Bare earth with renaturalization	18,192.00	10,500.00	0.00	0.00	0.00	18,192.00
M2F	Mner i Siperm	Broadleaved forests	0.00	0.00	0.00	0.00	0.00	0.00
M1O	Mner i Siperm	Orchard	18,192.00	10,500.00	950.00	11,400.00	34,154.40	63,746.40
M1P	Mner i Siperm	Cultivated meadow (alfalfa)	18,192.00	10,500.00	700.00	8400.00	34,154.40	60,746.40
M1F	Mner i Siperm	Broadleaved forests	0.00	0.00	0.00	0.00	0.00	0.00
M1DF	Mner i Siperm	Degraded forest	0.00	0.00	0.00	0.00	0.00	0.00
M2P	Mner i Siperm	Cultivated meadow (alfalfa)	18,192.00	10,500.00	700.00	8400.00	34,154.40	60,746.40
M3P	Mner i Siperm	Pasture—meadow (alfalfa)	18,192.00	10,500.00	700.00	8400.00	34,154.40	60,746.40
M4P	Mner i Siperm	Pasture—meadow (alfalfa)	18,192.00	10,500.00	700.00	8400.00	34,154.40	60,746.40

[1] Obtained by summing the replacement cost, the income loss, and the forest maintenance prize for 12 years.

Table A5. Financial convenience in the transformation of agricultural land and pastures into forests (cost–benefit analysis and replacement cost).

Sample Plot Code	Land Use Classes (Corine Land Cover 2012)	Total Tons of CO_2 (EUR)	Monetary Revaluation of Habitat Quality 2007–2018 (EUR)	Agric. and Forestry Production (EUR/ha)	K (EUR/ha)	P (EUR/ha)	CES (EUR/ha)	Total ES [1] (EUR/ha)	Total for 12 Years (EUR/ha)	Replacement Cost (EUR/ha)	Lost Income (EUR/ha)	Lost Income for 12 Years (EUR/ha)	Maintenance (EUR/ha)	Total Cost [2] (EUR/ha)	Economic Convenience (EUR/ha)
ZB5P	Pasture	32.07	2982.09	326.00	249.76	3.66	5.57	3509.16	10,230.01	18,192.00	0.00	0.00	34,154.40	52,346.40	42,116.39
ZB4P	Pasture	24.11	2930.39	326.00	188.80	2.77	5.51	3477.58	9430.53	18,192.00	0.00	0.00	34,154.40	52,346.40	42,915.87
ZB3P	Pasture	32.13	2923.44	326.00	246.36	3.61	5.42	3537.06	10,220.64	18,192.00	0.00	0.00	34,154.40	52,346.40	42,125.76
ZB4O	Orchard	348.94	0.00	35,320.50	1641.19	224.22	2.20	37,540.37	450,418.10	18,192.00	950.00	11,400.00	34,154.40	63,746.40	−386,671.70
ZB2P	Pasture	57.38	2931.38	326.00	444.61	6.52	5.45	3771.34	12,945.55	18,192.00	0.00	0.00	34,154.40	52,346.40	39,400.85
ZB4F	Conifer forests	64.11	0.00	2600.88	201.93	3.34	2.45	2872.70	34,443.06	0.00	0.00	0.00	0.00	0.00	no
ZB3F	Conifer forests	0.95	2377.92	2600.88	245.92	4.07	6.00	5235.74	36,599.82	0.00	0.00	0.00	0.00	0.00	no
ZB2F	Oak forest with pasture	0.34	2203.63	326.00	234.04	3.43	5.46	2772.90	8969.40	0.00	0.00	0.00	0.00	0.00	no
ZB1P	Conifer forests	0.91	2524.45	2701.08	203.46	3.37	6.39	5439.66	37,430.27	0.00	0.00	0.00	0.00	0.00	no
ZB3A	Agric. land (corn)	0.87	0.00	3948.00	612.86	21.72	3.11	4586.56	55,001.41	18,192.00	700.00	8400.00	34,154.40	60,746.40	5744.99
ZB2A	Agric. land (corn and beans)	0.88	0.00	5757.50	990.71	35.11	2.20	6786.40	81,410.36	18,192.00	700.00	8400.00	34,154.40	60,746.40	−20,663.96
ZB1A	Forage	0.90	0.00	2086.00	1086.92	38.52	2.20	3214.54	38,548.04	18,192.00	64.00	768.00	34,154.40	53,114.40	14,566.36
ZB4B	Bare lands	0.06	0.00	0.00	0.00	0.00	5.89	5.95	0.68	18,192.00	0.00	0.00	34,154.40	52,346.40	52,345.72
ZB3B	Bare lands	0.04	0.00	0.00	0.00	0.00	2.49	2.53	0.42	18,192.00	0.00	0.00	34,154.40	52,346.40	52,345.98
ZB2B	Bare lands	0.03	0.00	0.00	0.00	0.00	2.45	2.48	0.38	18,192.00	0.00	0.00	34,154.40	52,346.40	52,346.02
ZB1B	Bare lands	0.01	0.00	0.00	0.00	0.00	6.39	6.40	0.15	18,192.00	0.00	0.00	34,154.40	52,346.40	52,346.25
M1B	Bare earth with renaturalization	0.23	0.00	0.00	534.15	5.40	1.47	541.24	6477.26	18,192.00	0.00	0.00	0.00	18,192.00	11,714.74
M2F	Broadleaved forests	0.40	0.00	1147.93	14.02	11.22	1.48	1175.05	14,082.79	0.00	0.00	0.00	0.00	0.00	no
M1O	Orchard	0.66	5156.44	32,843.33	0.00	0.00	5.60	38,005.73	399,283.96	18,192.00	950.00	11,400.00	34,154.40	63,746.40	−335,537.56
M1P	Cultivated meadow (alfalfa)	0.30	3867.06	2114.00	635.31	7.74	5.64	6630.05	36,955.30	18,192.00	700.00	8400.00	34,154.40	60,746.40	23,791.10

Table A5. *Cont.*

Sample Plot Code	Land Use Classes (Corine Land Cover 2012)	Total Tons of CO_2 (EUR)	Monetary Revaluation of Habitat Quality 2007–2018 (EUR)	Agric. and Forestry Production (EUR/ha)	K (EUR/ha)	P (EUR/ha)	CES (EUR/ha)	Total ES [1] (EUR/ha)	Total for 12 Years (EUR/ha)	Replacement Cost (EUR/ha)	Lost Income (EUR/ha)	Lost Income for 12 Years (EUR/ha)	Maintenance (EUR/ha)	Total Cost [2] (EUR/ha)	Economic Convenience (EUR/ha)
M1F	Broadleaved forests	0.40	2900.63	1147.93	251.63	1.21	5.67	4307.47	19,714.71	0.00	0.00	0.00	0.00	0.00	no
M1DF	Degraded forest	0.39	2905.11	653.52	0.00	0.00	5.67	3564.69	10,752.03	0.00	0.00	0.00	0.00	0.00	no
M2P	Cultivated meadow (alfalfa)	0.45	3480.83	2114.00	220.71	2.69	5.67	6184.36	31,895.10	18,192.00	700.00	8400.00	34,154.40	60,746.40	28,851.30
M3P	Pasture—meadow (alfalfa)	0.44	3863.92	770.00	223.71	2.73	5.60	4866.40	15,826.51	18,192.00	700.00	8400.00	34,154.40	60,746.40	44,919.89
M4P	Pasture—meadow (alfalfa)	0.45	3862.22	770.00	310.86	3.79	5.60	4952.92	16,883.41	18,192.00	700.00	8400.00	34,154.40	60,746.40	43,862.99

[1] Obtained by summing the values of CO_2 (EUR/t), the monetary revaluation of habitat quality (EUR/ha), agricultural and forestry production (EUR/ha), K, P (EUR/ha), and CES (sustainable tourism suitability) (EUR/ha). [2] Obtained by summing the replacement cost, the income loss, and the maintenance prize for 12 years.

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