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Ecosystem Services Valuation for the Sustainable Land Use Management by Nature-Based Solution (NbS) in the Common Agricultural Policy Actions: A Case Study on the Foglia River Basin (Marche Region, Italy)

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Abstract: Agricultural land is a very important ecosystem that provides a range of services like food, maintenance of soil structure, and hydrological services with high ecological value to human wellbeing Ecosystem Services (ESs). Understanding the contribution of different agricultural practices to supply ESs would help inform choices about the most beneficial land use management. Nature-based Solutions (NbS) are defined by IUCN (International Union for Conservation of Nature) as actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges (e.g., climate change, food and water security, or natural disasters) effectively and adaptively, while simultaneously providing human wellbeing and biodiversity benefits. Some actions farmers can implement in the new Rural Development Programs (RDP 2021–2022 and 2023–2027) can be considered as NbS and could affect the quantity, quality, and time of some ESs related to water regulation and supply, N adsorption and erosion protection. This study aims to evaluate these ESs in different scenarios in the upper Foglia river basin (Italy) and at a local scale (farming), and to highlight the issue to compensate farmers for the production of public goods which benefit the whole society (ESs) by the implementation of RDP's actions. These scenarios highlight how actions have positive effects on ecosystem services and their economic value related to land use management, on maintaining agricultural practices by integrating Water Frame Directive (2000/60/EC), Directive 2007/60/EC on the management of flood risks and highlighting the potential role of farmers in a high diversity landscape. This study highlights a new way to evaluate the processes of natural capital in the production of public goods, which benefits the whole society (ESs), by emphasizing the economic and environmental role of farmers in producing them and putting on the table data to trigger a PES (Payment for Ecosystem Services) mechanism. To facilitate decision making, robust decision support tools are needed, underpinned by comprehensive cost-benefit analyses and spatially modeling in which agriculture can be a strategic sector to optimize food production and environmental protection in harmony with the Farm to Fork (F2F) strategy.

Keywords: ecosystem services; nature-based solutions; conservative agriculture; erosion protection; water regulation and supply; N balance

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1. Introduction

Agriculture is a dominant form of land management worldwide, and agricultural ecosystems account for almost 40% of land area [1]. In the European Union (EU) territory, rural areas account for over 77% (47% farmland, 30% forests) and their inhabitants, farming communities and other residents, representing approximately half of the entire population. The EU's Common Agricultural Policy (CAP) aims to support agriculture to ensure food security (in the context of climate change) and to promote sustainable and balanced development throughout the European rural areas, including those where production conditions are difficult [2]. Furthermore, there is a growing need for rapid and extensive actions to avoid the serious impacts of climate change, whose risks are at the top of the rankings in terms of impact and probability over the next 10 years [3]. The most worrying events are the floods triggered by extreme storms with possible landslides, especially in rural areas.

Even for hill and mountain areas, agricultural and forestry activities have been the main territorial modeling factors, in some cases creating very suggestive landscapes, but also affecting the territories often arranged for the degradation of soils and hydro-geomorphological instability [4]. Particularly in Italy, with a man's widespread presence in a differentiated landscape, specific agricultural and forestry practices have built an extensive water regulation network and stabilization of slopes contrasting erosion, especially in the past [5].

This work aimed to evaluate Ecosystem Services (ESs) as a benefit to the population provided by natural capital, associated with the water regulation (quality and quantity), soil erosion and N adsorption. The ESs were evaluated by comparing different scenarios provided by agriculture actions as derived from the Rural Development Programs (RDP) scheme (2014–2020), in an ecological Functional Unit (sub-basin of the Foglia river, Central Apennines) and at the local scale, to highlight the issue to economically recognize farmers for the production of public goods (ES), which benefits the whole society, emphasizing the economic and environmental role of farmers in producing them. Since the 1950s, the agriculture intensification with monoculture systems, the intensive tillage, and the high applications of fertilizers and pesticides maximizing crop and livestock production caused the loss of environmental quality and human well-being (landslide, flood, etc.) with higher costs recovery for the local communities [6–8].

Given this scenario of adaptation to climate change and improving the resilience of the landscape, agriculture is called upon to perform several functions: to meet the needs of citizens concerning the supply (availability, price, variety, quality, and safety); to protect the environment and ensure farmers a decent standard of living. At the same time, it is necessary to preserve rural communities and landscapes as a valuable part of Europe's heritage.

Since the mid-1980s, the European Commission introduced a range of policies. Over the last two decades, the CAP has been reformed and modified following three priorities: efficient food production, sustainable management of natural resources, and balanced development of the rural areas across the EU [9].

From CAP, the RDP are elaborated by the Member States to target funding from the European Agricultural Fund for Rural Development (EAFRD) to farmers [10]; it considers the agricultural sector as a key component in a sustainable economy [11] and Reg. (EU) 1305/2013 of the European Parliament and the Council on support for rural development by the EAFRD introduces Agri-Environmental-Climate (AEC) measures (art. 28) [12] and Agri-Environmental Schemes (AES) that play a crucial role for meeting society's demand for positive environmental outcomes from agriculture [13]. Whereas agricultural systems produce most of our food, they drive significant environmental degradation. This tradeoff between development and environmental conservation objectives is not an immutable outcome as agricultural systems are simultaneously dependents and providers of ecosystem services [14,15] depending on agricultural practices.

Furthermore, the enhancement of ESs needs to be addressed at different scales and should include the interaction between agriculture practices conserving biodiversity and stakeholders (farmers, managers, policymakers, etc.) to optimize service delivery [16]. AES represent one of the main tools of RDP: they are packages of actions implemented voluntarily by farmers who receive financial support in return for adopting environmentally-friendly practices [17], that could be optimized to reduce the adverse effects of agriculture, as improving water quality [18].

In particular, sustainable management of natural resources and climate action is one of the three objectives of the CAP post-2013 [19] and the new CAP (2023–27) eco-schemes, providing stronger incentives for climate-and environmentally-friendly farming practices and approaches (such as organic farming, agroecology, carbon farming, etc.) as tools to the environmental care and landscapes objectives. These actions can be considered Nature-based solutions (NbS), namely solutions inspired and supported by nature, which are cost-effective and simultaneously provide environmental, social, and economic benefits and help build resilience. Such solutions bring more and more diverse, natural features and processes into landscapes and agroecosystems through locally adapted, resource-efficient, and systemic interventions [20].

In addition, one of the most innovative aspects of CAP post-2013 was the introduction of payments for agricultural practices beneficial for the climate and the environment, which is generally referred to as "the greening component with measures as to comply with crop diversification, requirements, to maintain permanent grassland and to have ecological focus areas on farmland" [21]. The greening component has a prominent role in ensuring biodiversity objectives and the potential to protect and support ecosystems producing important ESs [11–21]. Consequently, the effect on the environment has been strengthened, providing payments to farmers who make commitments for making mandatory greening actions in order to get direct payments (1st pillar) and developing AEC measures in the EU's rural development policy (2nd pillar) through a set of actions relating to environmental protection and maintenance of the landscape, also as an adaptation to climate change. Regulation 1305/2013 stipulates that "restoring, preserving and enhancing eco-systems related to agriculture" and "promoting resource efficiency and supporting the shift towards a low carbon and climate-resilient economy" are two of the EU's six policy priorities for its rural development policy in the period 2014–2020 with payments to support afforestation, agroforestry, organic farming; compensating farmers for costs and income loss associated with restrictions introduced by the Wild Birds, Habitats and/or Water Framework Directives, etc. [21]. These aspects are increasingly topical and urgent in the next CAP (2023–2027) and are the target of objectives of agriculture and climate mitigation (obj. no. 4), efficient soil management (obj. no. 5), biodiversity, and farmed landscapes (obj. no. 6).

These measures are aimed to encourage farmers to protect and enhance the environment on their farmland by compensating them for the provision of ESs [9]. Whittingham [22] highlights the link between ESs and AEC payments and suggests that the compromise strategies combining patterns of biodiversity and ecosystem services may be the best solution for future initiatives, especially when operating at scale landscape [23,24]. In this context, agriculture can affect a wide range of ESs, including food and materials for human consumption, but also non-market services, such as water quality and quantity, soil and air quality, carbon sequestration, pollination services, seed dispersal, pest mitigation, biodiversity, and protection from disturbances [25–28].

These ESs are not usually considered in the development of agricultural management strategies [29] because they are not directly linked to the market as food or raw materials [4] or lack incentives for the provision that come with prices [15].

However, in addition to forest ecosystems [30,31], the contribution of agricultural land and practices on water supply and erosion control (regulating services) is mainly associated with the reduction of water losses and sediment by runoff or water evaporation that contribute to water retention and groundwater recharge.

When agronomic management practices are performed with respect to environmental quality, agroecosystems can produce high ecological and economical values and public goods, appreciated by people but that often are not recognized by market values [15]. Reed et al. [32] affirm that to link ecosystem service provision with payments to farmers, it is necessary to identify and put a price on each service, either directly by offering contracts for a set of outcomes or indirectly by offering contracts for a set of actions. Farmers' behavior and motivations play a central role in terms of overall measure uptake, and therefore policy success at the European [33] as well as at the Italian level [34,35], highlighting the importance of a positive attitude towards nature conservation by farmers as one motivation for participation in AEC measures [36].

Marche Region in the RDP 2014–2020 and for 2021 defines the Agro-Environmental Agreement (AEA) as "a set of commitments for farmers in a limited area, supported through a mix of RDP measures activated to reach specific environmental goals". In addition, other recent policies promote innovative management regimes, particularly for ecosystem services of regulation and water-related, which can provide potential funding mechanisms to integrate the actions of the Biodiversity Strategy 2030 [11] with the actions of the Water Framework Directive (2000/60/EC-WFD) and the Directive 2007/60/EC on the assessment and management of flood risks, by including in the public and/or private sectors actions aimed to preserve and enhance ecosystems and their services by the green and blue infrastructure and the restoration of degraded ecosystems.

Traditionally, agroecosystems were considered primarily as a source of provisioning services associated with food and raw materials production (fiber and biomass for bioenergy) [15,21,37], sometimes reducing other ecosystem services [38]. The efforts of farmers have focused on the provision of services as they are strongly linked to the market that generates income. At the same time, there are also non-market services while their contribution is reduced or absent due to unsustainable agricultural practices [29] that can cause serious instability problems.

Studies suggested that it may be possible to manage agroecosystems to support many ecosystem services while still maintaining or enhancing the provisioning services that agroecosystems were designed to produce [29,39,40] considering how agricultural practices can result in synergies between agricultural production and ESs [41].

In this context, regulation services are the most important related to the water cycle and soil instability, taking a different level of interest from other ESs [42,43]. The availability of water, both in terms of quantity and quality, is also heavily influenced by the functioning of ecosystems [38–44]. For example, the secondary drainage network may be an important sink for bioavailable nitrogen owing to its hydrological connections with terrestrial systems, high rates of biological activity, and streambed sediment environments that favor microbial denitrification [45].

The agroecosystems depend heavily on a cluster of regulation ESs, provided by natural ecosystems that can be measured in an Ecological Functional Unit in which is possible to determine levels of natural capital usability, as security of ecosystem function supporting other services, and also as tools to evaluate agriculture's dependence on natural capital or to address sustainable planning [43–46].

Many studies try to evaluate the value of agroecosystem services [8,15,47] also in Italy [29,48] and how agri-environment schemes under the Common Agricultural Policy could be adapted to derive a higher return of ecosystem services from agricultural land [32], but the incorporation of ecosystem services into agricultural land-use decision-making remains limited [7].

Extensive literature, starting from the paper of Costanza et al. [49], evaluates the ESs at a global or local scale [50–52]; however, there is a lack of detailed understanding of ESs in a different scenario of agricultural practices [53], especially in Italy where the focus was on mainly an in peri-urban context [54,55].

We conducted an ESs evaluation related to water regulation (quality and quantity) and soil erosion to show how agriculture actions as derived from the RDP scheme (2014–2020), can be a tool to highlight the role of farmers in protecting the landscape, contrasting climate change, producing public goods, and also economically recognizing their role and involve it in a PES (payment for ecosystem services) mechanism [56].

Concerning this, Jack [21] suggests that the private markets may increasingly develop to provide payments for landowners who help protect ecosystem services.

This study was supported by "Consorzio di Bonifica delle Marche" Institution, with the aim to involve the farmers in an AEA to solve problems of water quality and erosion of the study area that are also in accordance with the results required by the WFD (2000/60/EC) and the Directive on the assessment and management of flood risks (2007/60 /EC).

In this research, we have tried to make NbS solutions concrete with actions based on the management of natural dynamics, capitalizing on the accumulated knowledge of ESs. In that sense, we define nature-based solutions as any transition to the use of ESs with decreased input of non-renewable natural capital and increased investment in renewable natural processes.

This study starts with the identification of the ecological Functional Unit in which ESs as water regulation and supply, soil erosion, and N adsorption are evaluated in different scenarios of agricultural practices with the application of the AEA to understand how CAP's actions are able to produce a public benefit and to recognize the role of farmers in producing it. Subsequently, we evaluated the same ES at a farming scale to inform farmers on the value of some agricultural practices in maintaining ecosystem services and producing benefits to the local population and put this information on decision makers' attention to trigger PES mechanisms.

2. Study Area

The study area is the Foglia River Basin, located in Italy's northern region of the Apennine Mountains, the northern Marche Region (Figure 1). This river basin, with a torrential regime, is representative of many others reaching the Adriatic Sea in terms of geomorphology and socio-economic dynamics.

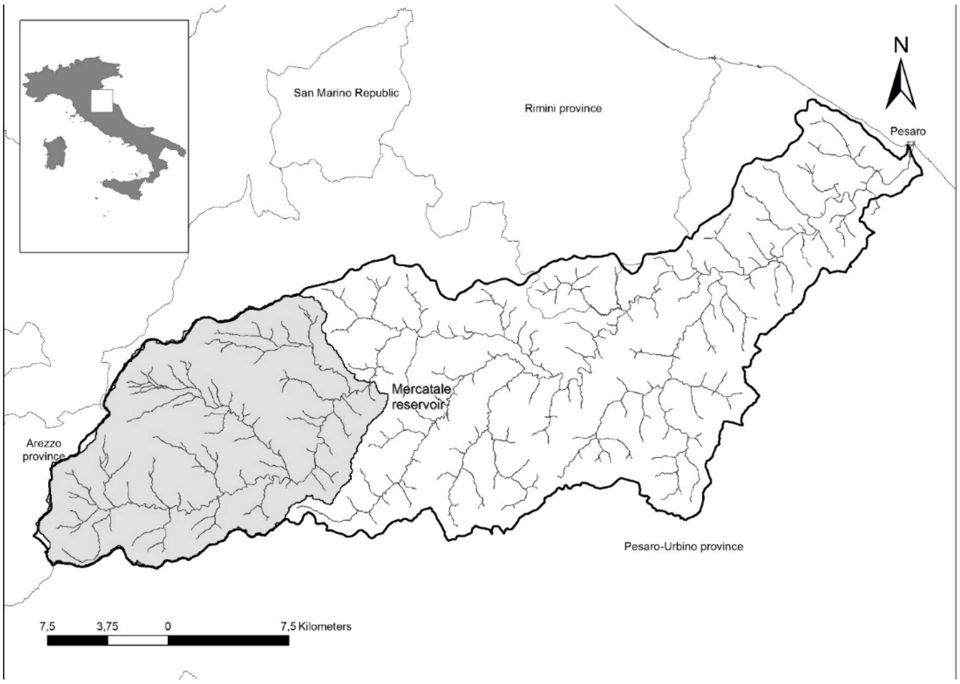

Figure 1. The study area of the upper Foglia river basin.

In particular, we focused on the upper part of the Foglia river basin that covers approximately 22,720 ha (total 70,000 ha). It is characterized by a combination of agricultural areas (43%), forests (40%), and natural and semi-natural grasslands (11%); urban areas cover 6% of the total area as derived by land use map [57].

The agricultural and zoo-technical activities in this area caused water degradation as indicated by the Regional Environment Protection Agency (ARPA) data on water quality monitoring (www.arpamarche.it accessed on 12 July 2015), and in the middle and lower part of the river basin, there are high irrigation, drinking and industry demands and water quality problems (namely, pollution by nitrates and eutrophication). Since the 1980s, progressive deterioration in groundwater quality and increasing demand has generated a greater use of surface water as the main source (56%), thus requiring physical and chemical treatments. In addition, several minor water systems (<2000 AE) are not able to remove all nutrients (e.g., organic load); many of these systems are not connected to drain networks.

Furthermore, a high percentage of the river basin risks soil erosion: 33% of land use types in the Foglia river basin are at a relatively high erosion risk (5–20 t ha^{-1} yr^{-1}) [58].

These problems are connected to the Mercatale reservoir located in the study area, with a water storage capacity of approximately 5.91 Mm^3, currently reduced to 4.8 Mm^3 caused by silting. Water stored in this basin is used for irrigation (3500 ha) and drinking water (1 Mm^3 for 8 municipalities) from the “Consorzio di Bonifica delle Marche” Institution.

The Mercatale reservoir represents an important reservoir to support water demand that significantly increases during summer because of 5.7 million tourists, especially along the coast, in addition to the 130,000 residents of the study area.

The timing of water demands and availability and erosion issues critically depend on land use in the upper regions of the basin. This area was one of those selected by the Marche region to apply an Agro-Environmental Scheme (AES) in which some agricultural practices can promote ecosystem services.

3. Materials and Methods

Considering the problems of the study area (water regulation/supply/quality and siltation connected to the Mercatale reservoir), 3 ESs were investigated, as described in the following paragraphs.

3.1. Water Regulation and Supply

The water regulation and supply services (WRSS), (Equation (3)), were estimated as composed by the volume of available water (*AW*) and considering the supply portion withheld by different land use as the contribution to water storage and natural release efficiency of water conservation (EW).

AW, (Equation (1)), was evaluated by considering each land use class extension’s average surplus values (S). In particular, surplus values are approximated by the difference between precipitation input (P) and real evapotranspiration (ETR) [59], as described in Morri et al. [30].

$$AW = \sum S_{ij} \times Aj \tag{1}$$

where S_{ij} is surplus (mm) over i-pixel with j-land cover typology and Aj is the land cover extension (m^2).

The EW coefficient for different land cover typologies derived from Hümann et al. [60] for forest and was elaborated from Nedkkov and Burkhard [61] for the other land use classes (Table 1).

Table 1. Efficiency of water conservation provided by different land use classes (derived from Humann et al. [60] for forest and elaborated from Nedkkov and Burkhard [61] for the other land use classes).

Land Use Classes	Efficiency of Water Conservation EW (% of S)
Urban area (industrial, road, urban fabric); bare rocks	0
Arable land	17
Continue and discontinue grasslands; complex cultivation patterns; Sclerophyllous vegetation	33
Shrubby buffer strips; vineyards; transitional woodland-shrub	50
Broad-leaved forest, hygrophilous forest, mixed forest; arboreous buffer strips	67
Coniferous forest or mixed (mainly coniferous)	83
Water bodies, water courses	100

This coefficient was applied to the *AW* value for each land use class (Equation (3)) to evaluate water storage and release regulation. Urban areas have a value of 0 considering that available water is not stored in this kind of land cover and can contribute to runoff or overland flow.

For the S evaluation, meteo-climatic data were related to monthly precipitations data for the period 1982–2011 from Regional Information System Weather-Hydro-pluviometric-SIPMIP (http://84.38.48.145/sol/indexjs.php?lang=it, accessed on 12 July 2015).

The period 1982–2011 was selected to have an historical series of data and consider the start of global climatic change to understand if the hydrologic cycle can depend on it [62–64]. Maps of climatic average annual and monthly data were created (temperature and precipitation).

Real evapotranspiration (*ETr*) was calculated as described in Zhang et al. [65] that consider the w parameter (plant-available water coefficient) related to land cover to simulate different scenarios considering different land use in the study area (Equation (2)).

$$ETr = 1 + \frac{W\,\frac{E0}{P}}{1 + W\,\frac{E0}{P} + \left(\frac{EO}{P}\right)^{-1}} \quad (2)$$

where P is the precipitation, $E0$ is the potential evapotranspiration calculated as indicated in Zhang et al. [65], and w are the parameters for forests (2), grassland and arable lands (0.5), urban or bare rock (0.1). For the other land use classes not considered by Zhang et al. [65], for the w parameter evaluation, we constructed a regression line with the Kc parameter that describes the effect of both crop transpiration and soil evaporation as modeled by FAO [66] (Figure 2). Data are shown in Table 2.

Finally, the economic value of water regulation and supply service (*WRS* expressed in €) was calculated as described in Equation (3):

$$WRSS = CDW \times \sum j \sum i \times EWj \times AWij \quad (3)$$

where *CDW* is the price of a unit of bulk water (0.35 €/m^3) defined by the local water service company (Hera and Marche Multiservizi), *EWj* is the retaining coefficient for *j*-land cover typology, and *AWij* is available water over *i*-pixel with *j*-land cover typology.

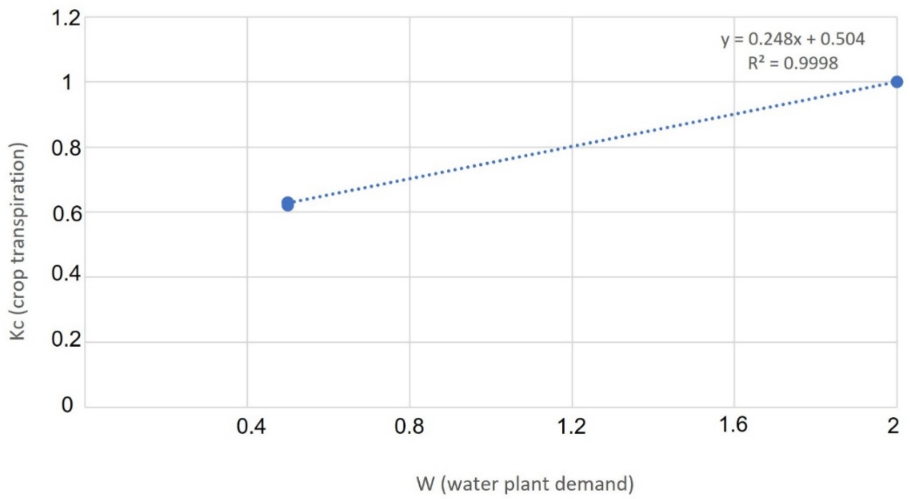

Figure 2. Regression line from Kc parameters (FAO) and W parameters for the land use classes not indicated in Zhang et al. [65].

Table 2. Parameters used for evaluation of soil loss by erosion and the real evapotranspiration.

Land Use Classes	C	Kc	W
Transitional woodland-shrub	0.01	0.8	1.2
Sclerophyllous vegetation	0.01	0.8	1.2
Industrial and commercial units	0	0.001	0.1
Sport and recreation ports	0.01	0.63	0.5
Green urban areas	0.01	0.63	0.5
Water bodies	0	1	0.1
Broad-leaved forest (Fagus)	0.01	1	2
Broad-leaved forest (Quercus)	0.01	1	2
Hygrophilous forest	0.01	1	2
Coniferous forest	0.01	1	2
Broad-leaved forest	0.01	1	2
Mixed forest (mainly coniferous)	0.01	1	2
Mixed forest (mainly broad-leaved)	0.01	1	2
Construction sites	0	0.001	0.1
Water courses	0	1	0.1
Shrubby buffer strips	0.01	0.63	0.5
Arboreous buffer strips	0.01	0.63	0.5
Continue grasslands	0	0.001	0.1
Discontinue grasslands	0.55	0.001	0.1
Road and rail networks	0.335	0.62	0.5
Bare rocks	0.55	0.001	0.3
Arable land	0.335	0.67	0.8
Arable land-bare surface	0	0.001	0.1
Complex cultivation patterns	0.55	0.7	0.2
Urban fabric	0.28	0.67	0.5
Vineyards	0.01	0.8	1.2
Grassing vineyards	0.01	1	2

3.2. *Erosion Protection*

The study area's erosion protection service (EP) emerges as a decrease in soil loss by erosion in different scenarios. Thus, the economic value of soil protection was estimated as the avoided cost of restoring soil where erosion might occur, similarly as described in Morri et al. [30]. Because conservative agricultural management is the most effective in soil protection, this value was estimated by the difference in the potential erosion between different scenarios applying conservation agriculture management.

The difference of soil loss expressed as ton ha^{-1} y^{-1} from different scenarios approximated the contribution to erosion reduction and was expressed as a benefit of the conservative agriculture measures for soil protection. Such a contribution was multiplied by the average cost for transporting and restoring a unit volume of soil and divided by the average soil density, as expressed in Equation (4), where C is the cost for transporting and locating a unit volume of soil (41 €/m^3) [67], $X_2 - X_1$ is the difference between the average soil loss (t ha^{-1} yr^{-1}) provided by different scenarios, and SD is the soil density (1.4 g/m^3) of the study area [68].

$$\mathrm{EP} = \mathrm{C} \times (\mathrm{X}_2 - \mathrm{X}_1)/\mathrm{SD} \tag{4}$$

To evaluate the soil loss as erosion risk by water in the study area we used the Revised Universal Soil Loss Equation (RUSLE model) [69], as expressed by Equation (5):

$$\mathrm{A} = \mathrm{R} \times \mathrm{K} \times \mathrm{LS} \times \mathrm{C} \times \mathrm{P} \tag{5}$$

where:

A = estimated average soil loss (ton ha^{-1} y^{-1}).
R = rainfall-runoff erosivity factor (Jm^{-2} mmh^{-1}).
K = soil erodibility factor (t ha^{-1} R unit).

L = slope length factor (dimensionless).
S = slope steepness factor (dimensionless).
C = cover-management factor (dimensionless).
P = support practice factor (dimensionless).

The R factor quantifies the effect of raindrop impact and reflects the amount and rate of runoff likely to be associated with rain. For the study area, R-values were derived by Diodato [70] using regional relationships for estimating the erosion index from only three rainfall parameters as annual precipitation (a), annual maximum daily precipitation (b), and annual maximum hourly precipitation (c) that are reported in Italian Hydrographic Service newsletters as described in Equations (6) and (7):

$$EI_{30\text{-annual}} = 12.142 \times (\text{abc})^{\ 0.6446} \tag{6}$$

where $EI_{30\text{-annual}}$ (in MJ mm ha^{-1} y^{-1}) is the annual erosive empirical index to calculate R as:

$$\text{R} = \frac{1}{N} \times \sum\nolimits_{1}^{N} EI_{30-\text{annual}} \tag{7}$$

where N is the year period.

K factor was provided by the Agency for Agro-food Sector Services of the Marche Region (ASSAM) [58]; LS factors were calculated by using the semiautomatic method for ARCGIS 10 of Pelton et al. [71] (http://gis4geomorphology.com/ls-factor-in-rusle/, accessed on 4 June 2015).

C factor depends on land use, and it varies from eroded cultivated soil (C = 0) to eroded non-cultivated soil (C = 1). In the study area, the C factor was defined from the land use map for each land cover class as indicated in Table 2 and derived from ASSAM.

P factor reflects the impact of support practices as the average annual erosion rate. It is the soil loss ratio with contouring and/or strip cropping to that with straight row farming up-and-down slope. *P*-values for different slope classes were used as indicated in Table 3 for the contouring practices that can be potentially developed in the study area.

Table 3. *p* factor values for contouring practices for each slope class (from Kirkby and Morgan [72]).

Erosion Classes	Slope Classes (%)	*p*-Value
1	1–2	0.6
2	3–8	0.5
3	9–13	0.6
4	14–16	0.7
5	17–20	0.8
6	21–25	0.9

We estimated average soil loss and produced maps for the study area for each of the different scenarios considered.

3.3. N Balance

N balance was estimated for the Foglia river and the upper river basins. It was derived from the soil system budget [73] developed by the Italian Nitrogen Network [74], to verify whether uncoupled input and output terms generate N surplus or deficit. A positive N value means that a certain nitrogen amount ("N surplus") is either retained within soils or run off to surface water and leached to groundwater. A negative N means that input terms are not sufficient to sustain crop requirements and atmospheric losses (denitrification and volatilization).

The soil system budget was calculated on an annual basis (year 2010) as the net difference between N inputs (livestock manure, synthetic fertilizers, atmospheric deposition, biological fixation, and wastewater sludge) and N outputs (crop uptake, ammonia volatilization and denitrification in soils) within the catchment's agricultural land (for details see Soana et al. [75]).

N budget calculations were performed at a spatial resolution of individual municipalities (35) using farming census data (ISTAT, National Statistics Institution, 6th Agricultural Census 2010; http://censagr.istat.it/dati.htm, accessed on 4 June 2015), then aggregated to the catchment scale employing GIS techniques.

Final data of balance was expressed in tons N yr^{-1}.

For the scenario, we calculated how the wooded buffer strips contribute to N adsorption, referred to N balance of the upper Foglia river basin. For the N adsorption provided by wooded buffer strips (3 m × 1000 m), we considered the value of 405 kg N and the economic value of 0.7 €/t for the denitrification service [76,77].

3.4. Developing Scenarios

3.4.1. Scenarios at Upper River Basin Scale

To understand how the land use change at the upper river basin scale can improve the quality of the ecological system and ecosystem services values, we suppose 4 scenarios that could be realized with the application of the AEA in the RDP of Marche Region (2014–2020). We have considered different actions that can be involved in AEA, for example, wooded buffer strips provide many ecosystem services relating to mitigating impacts of climate change and provide for water purification [78], or cover crops in vineyards can help mitigate many of the problems associated with excessive precipitation or soil erosion [79–95].

In particular, the scenarios are:

1. T0 scenario: state of the art from 2008 land use map [57] with 2% of the arable land cover as a bare surface in winter (Agriculture Regional Information System).
2. T0_bis scenario: improving from the T0 scenario, the Urban Development plan for discontinuous urban fabric, industrial units, services and public facilities, parking, roads.
3. AAA scenario: from the T0 scenario, some agri-environmental actions are developed: addition of wooded buffer strips (European Reg. n 1305/2013) [80] of 5 m along with the first drainage network and 3 m along with the secondary drainage network, grassing vineyards (measure 10.1 RDP 2014–2020), winter cover for arable land (measure 10.1 RDP 2014–2020), the addition of herbaceous vegetation (3 m) along the road neighboring arable land and along the erosion furrows (5 m), variation of P parameter about RUSLE model from 1 to 0.5 and 0.6 [72], considering that 15% of arable land (slope class < 13%) are subject to contour plowing (it is the farming practice of plowing and/or planting across a slope following its elevation contour lines. These contour lines create a water break, which reduces the formation of rills and gullies during times of heavy water run-off, which is a major cause of soil erosion).
4. AAA bis scenario: from AAA scenario, it is assumed that arable land with a slope > 20% is transformed into grassland (e.g., alfalfa). This action aims to promote land management that minimizes potential erosion. In particular, this action could permit the conversion of almost 4500 hectares of arable land in grasslands that represent a specific habitat for some species of animals and plants, increasing the biodiversity level.

3.4.2. Scenarios at Farming Scale

For the realization of scenarios at farming scale, we analyzed the local condition of agricultural practices, and we selected, based on local agronomist knowledge and on RDP measurement (2014–2020), the actions that could be undertaken by farmers in the study area, to facilitate erosion protection, water regulation and supply, and N adsorption. We selected two farms as a sample of approximately 189 (F1) and 118 ha (F2), with arable land surfaces of 157 and 89 ha, respectively.

We reject the realization of new:

- Vineyards: because of the failure of the production chain and the difficulties in promoting the product (high average age);

- Orchards: because of the high installation costs, the lack of fruit and vegetables local sector, and the inadequate training of farmers to never practiced crops;
- Olive groves: because of weather and altitude problems.

We supposed 4 scenarios for the 2 sample farms with more conservative measures from T0 to T3:

- T0: actual traditional agronomic practices;
- T1: minimum tillage practices in the 35% of arable land;
- T2: conservation agriculture techniques: no-tillage, direct seeding and working bands on arable crops, crop residues left in an agricultural field, ban on continuous cropping;
- T3: conversion of arable land to grassland, meadows permanent grass of specialized perennial crops (vines, olives, and fruit), and creation of not used buffer zones along the watersheds (5% of the farming area).

For these scenarios, we estimated the value of selected ESs and considered potential payments to farmers deriving from RDP measures adoption (€ ha^{-1}). In addition to erosion protection and water regulation and supply values, we also considered other benefits as CO_2 sequestration by soil (t ha^{-1}) by applying a carbon market price expressed as emission permit price of 31 €/t CO_2 [81], biodiversity increase (n. of earthworms) [82], fertility soil improvement (qualitative evaluation), and fuels use saving (l ha^{-1} as Kg ha^{-1} CO_2) deriving from LIFE project HELPSOIL data (http://www.lifehelpsoil.eu/en/, accessed on 10 April 2015). We did not apply the N balance at the local scale because the model was constructed for the river basin scale, and the minimum data set is municipal level.

For the water regulation and supply service, we considered the economic value as derived for the upper river basin (Supplementary Materials Table S1) but considering only the agricultural classes in retaining available water for the T1 and T2 scenarios and the grassland, buffer strips and grassing vineyards water retention value for the T3 scenario obtaining a value of 112 € ha^{-1} and 172 € ha^{-1}, respectively.

4. Results

4.1. Land Use Change

Land use transformations bring about changes in the provision of ESs. Table 4 indicates the land use change of different supposed scenarios. Data showed an increase of approximately 55 ha for industrial or commercial units, and 99 ha for urban fabric class considered as a land use unable to produce ESs. Expected scenarios provided an increase of approximately 33 ha of buffer strips (0.14%), grassing vineyards (0.1%), and a decrease of arable land with a bare surface (0.33%).

Continue grasslands increased approximately 200 ha from T0_bis to AAA scenario and strongly increased from T0 to AAA_bis scenario of approximately 4678 ha representing 28.6% of the total area (Table 4). Grassland extensively managed, as expected in the scenario, has a high capacity to deliver multiple ESs as parts of agricultural systems even if understudied [83].

4.2. Evaluation of Selected Ecosystem Services at Upper River Basin Scale

4.2.1. Water Regulation and Supply

Surplus data (mm) was derived from the water balance equation as the difference between precipitation and evapotranspiration. In the study area, the average real evapotranspiration value is approximately 566 mm/y from a minimum of 410 mm/y to a maximum of 685 mm/y. Considering evapotranspiration and climatic data, with an average precipitation value of approximately 1009 mm/y, surplus ranges from 217 mm/y to 730 mm/y with an average of 442 mm/y. Available water (m^3) was obtained using the average surplus value multiplied by the extension of each land use class.

Considering available water raster values for the extension of each land use class for the Foglia upper river basin, the study showed available water of approximately 100 Mm^3 for all scenarios without important variation.

Table 4. Land use classes extension and % for each scenario.

-	T0		T0_bis		AAA		AAA_bis	
-	**Area**							
-	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
Transitional woodland-shrub	682.0	3.0	682	3.0	681.9	3.0	681.9	3.0
Sclerophyllous vegetation	364.6	1.6	364.6	1.6	364.6	1.6	364.6	1.6
Industrial and commercial units	56.9	0.2	111.6	0.5	111.6	0.5	111.6	0.5
Sport and recreation ports	18.2	0.1	18.2	0.1	18.1	0.1	18.1	0.1
Green urban areas	352.7	1.5	333.5	1.5	330.6	1.5	330.6	1.5
Water bodies	54.6	0.2	54.6	0.2	54.6	0.2	54.6	0.2
Broad-leaved forest (Fagus)	35.6	0.2	35.6	0.2	35.6	0.2	35.6	0.2
Broad-leaved forest (Quercus)	6411.6	28.2	6410	28.2	6409	28.2	6409	28.2
Hygrophilous forest	245.7	1.1	245.1	1.1	245.1	1.1	245.1	1.1
Coniferous forest	489.8	2.2	489.6	2.2	489.3	2.1	489.3	2.1
Broad-leaved forest	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0
Mixed forest (mainly coniferous)	113.9	0.5	113.8	0.5	113.8	0.5	113.8	0.5
Mixed forest (mainly broad leaved)	2041.5	9.0	2041	9.0	2040	9.0	2040	9.0
Construction sites	3	0.0	2.2	0.0	2.2	0.0	2.2	0.0
Water courses	48.5	0.2	48.4	0.2	48.4	0.2	48.4	0.2
Shrubby buffer strips	0	0.0	0	0.0	25.3	0.1	25.3	0.1
Arboreous buffer strips	0	0.0	0	0.0	7.8	0.0	7.5	0.0
Continue grasslands	1842.4	8.1	1838	8.1	2039	9.0	6520	28.6
Discontinue grasslands	259.1	1.1	254	1.1	252.8	1.1	252.8	1.1
Road and rail networks	578.4	2.5	569.9	2.5	569.8	2.5	569.8	2.5
Bare rocks	228	1.0	228	1.0	226.9	1.0	226.9	1.0
Arable land	8663.8	38.1	8562	37.6	8407	36.9	3926	17.2
Arable land-bare surface	75.3	0.3	72	0.3	0	0.0	0	0.0
Complex cultivation patterns	54	0.2	54	0.2	52.6	0.2	52.6	0.2
Urban fabric	124.1	0.5	223	1.0	219.6	1.0	219.6	1.0
Vineyards	18.3	0.1	18.3	0.1	0	0.0	0	0.0
Grassing vineyards	0	0.0	0	0.0	17.9	0.1	17.9	0.1
Total	22,762.3							

Considering the percentage of retained water from different land use classes (Table 1), data showed a value of approximately 37 Mm^3 of available water stored and released in the T0 and AAA scenarios and almost 40 Mm^3 in the AAA_bis scenario corresponding to an economic value for the water regulation and supply service of almost € 14 $\times$ 10^6 (Table 5). Water regulation values are less in the scenario T0_bis because of more urban surface extension with respect to the T0 scenario.

Table 5. Available water and water regulation and supply service values for each scenario.

	Scenarios			
Available Water	**T0**	**T0_bis**	**AAA**	**AAA_bis**
Mm^3	100.73	100.77	100.66	100.72
Water regulation and supply service				
Mm^3	36.91	36.18	36.77	39.85
€ $\times$ 10^6 (0.35 € m$^{3-1}$ bulk water cost)	12.92	12.66	12.87	13.95
€ ha^{-1}	569	557	566	614

Detailed data for available water and stored and released water are described for each land use class in Supplementary Materials Table S1.

4.2.2. Erosion Protection

The RUSLE model application shows a soil loss of approximately 688,978 t/y for the T0 scenario, a slight decrease in the scenario AAA of approximately 650,000 t/y, and a hard soil loss in implementing conservative agricultural measures of AAA_bis scenario (Table 6 and Figure 3).

Table 6. Erosion protection value by erosion of each scenario.

	Scenarios			
	T0	**T0-bis**	**AAA**	**AAA_bis**
soil loss_Erosion (t y^{-1})	688,978	672,307	649,975	265,750
difference with t0 (t y^{-1})	-	−16,671	−39,002	−423,227
difference with t0 (%)	-	−2.4	−5.7	−61.4
difference with t0 (m^3 y^{-1}) (considering 1.4 gr/cm^3 soil bulk density)	-	−11,908	−27,859	−302,305
Erosion protection value (10^6 €) (41 €/m^3 Marche Region, 2010)	-	0.49	1.14	12.39
Forest area (ha)	9338	9336	9334	9334
Erosion protection value by forest (€)	784,407	784,189	784,031	784,031
Erosion protection value by applying RDP measures (€)	-	-	358,184	11,610,486
Erosion protection value by applying RDP measures (€ ha^{-1})			15.8	511

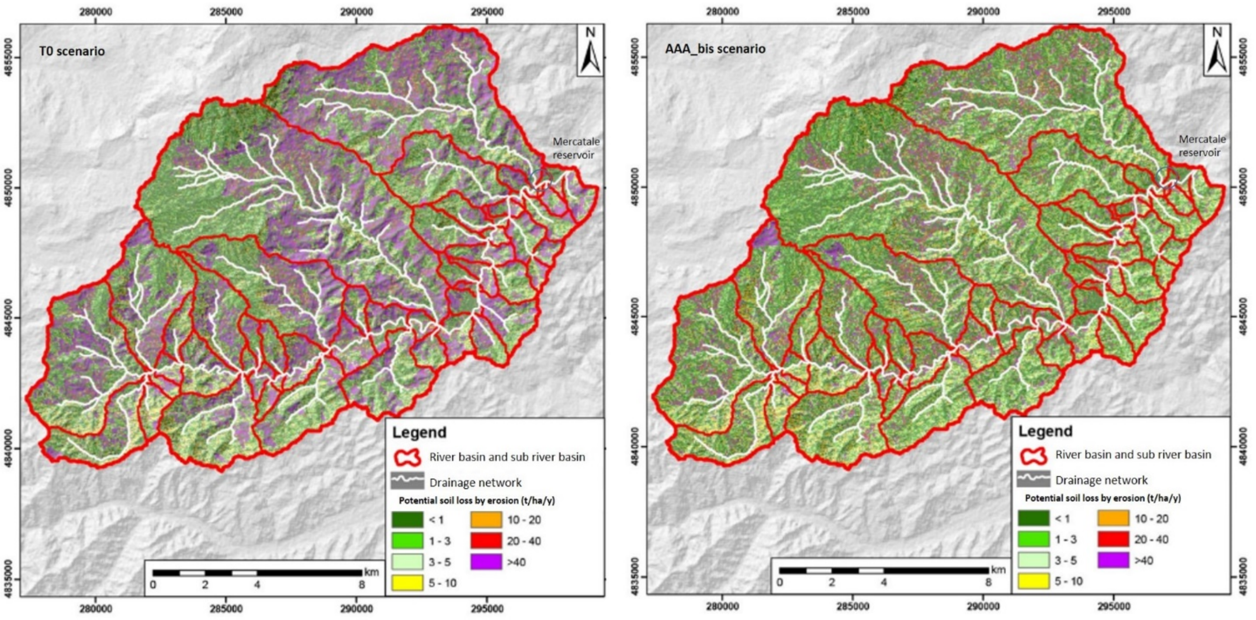

Figure 3. Potential soil loss by erosion in T0 scenario (**left**) and AAA_bis scenario (**right**).

Data showed a decrease of erosion of approximately 5.7% (39,000 t) from the T0 to AAA scenario and a very high decrease of over 60% (423,227 t) to AAA_bis scenario with the supposed transformation of arable land with a slope > 20% to grassland. From T0 to T0bis, data highlighted a slight decrease of soil loss by erosion due to a slight increase of artificial surface with a potential erosion equal to 0 in the RUSLE model.

Applying the 1.4 gr/cm^3 soil bulk density for the study area, the potential soil loss by erosion decrease is 11,908 m^3/y, 27,859 m^3/y, and 302,305 m^3/y for the T0_bis, AAA, and AAA_bis scenario, respectively.

The erosion protection value, applying the replacement cost of 41 €/m^3, is 0.49, 1.14, and 12.39 10^6 € for the T0_bis, AAA, and AAA_bis scenarios, respectively.

We considered the erosion protection value (€ ha^{-1}) provided by the forest as indicated in Morri et al. [30] for the same study area (84 € ha^{-1}) to separate the erosion protection value by applying RDP measures. The results of 84 €/ha for erosion protection by forest are similar to values reported by Li et al. [84], with a valuation developed in temperate forests.

For the AAA scenario, the erosion protection provided by RDP measures was 358×10^3 € and over 11×10^6 € for the AAA_bis scenario with values of 15.8 and 511 (€ ha^{-1}). This can be the value to put on the table to discuss the PES implication with recognizing the farmers' role to produce ESs.

4.2.3. N Balance

The application of the soil system budget as developed by the Italian Nitrogen Network shows for the Foglia river basin an N surplus of approximately 1727 Tons N yr^{-1} (Table 7).

Table 7. Soil system budget for Foglia and upper Foglia river basin.

	Soil System Budget Foglia River Basin		Upper Foglia River Basin	
Input	Tons N yr^{-1}	%	Tons N yr^{-1}	%
Livestock manure	1388	19	515	70
Synthetic fertilizers	520	7	104	14
Biological fixation	5075	71	72	10
Atmospheric deposition	172	2	45	6
Σ input	7156	100	736	100
Output	Tons N yr^{-1}	%		
Crop uptake	4918	91	292	62
NH_3 volatilization	320	6	119	25
Denitrification in soils	191	3	62	13
Σ output	5429	100	473	100
Input-output	1727		264	

The most important input is mainly due to biological fixation (71%) and livestock manure (19%), while the main output was performed by crop uptake (91%).

For the upper Foglia river basin (Figure 4), data showed a different input data: the most important N load derived from livestock manure (515 tN yr^{-1}) produced mainly by swine (45%) and cattle (35%) farming. Manure was followed in importance by synthetic fertilizers application (104 tN yr^{-1}). Biological fixation and atmospheric deposition were responsible for the remaining 16% of N input to agroecosystems. N input to agricultural lands in the upper basin municipalities ranged from 30 to 224 kg Nha^{-1}, and overall the mean input rate was 81 kg Nha^{-1}.

The total potential N output from agricultural lands was 473 tN yr^{-1} on an annual basis, with crop harvest representing the maximum sink, approximately 62% of total output. NH3 volatilization and denitrification in soils yielded annual fluxes to the atmosphere of 25% and 13% of total output, respectively. Annual N output from agricultural lands in the upper basin municipalities ranged from 27 to 92 kg Nha^{-1}, and overall, the mean output rate was 52 kg Nha^{-1}.

Upper Foglia N surplus represented 15% of the total Foglia river basin N surplus, and the higher value of N load corresponded to the area directly connected to the Mercatale reservoir that could affect water quality. Considering the buffer strips supposed in the AAA and AAA_bis scenarios (33 ha), they took up 45 t/y N, corresponding to 17% of upper river basin N surplus. Applying the value of denitrification actions, the N sequestration provided by buffer strips was €31,185.

4.3. Evaluation of Selected Ecosystem Services at Farming Scale

Data described in Table 8 highlight the erosion protection value of farmland 1 (F1) and farmland 2 (F2) in more conservative scenarios. It was about the range of €4450–4650 for the T1 scenario, €19,250–17,750 for the T2 scenario, and €24,900–22,700 for the T3 scenario for F1 and F2, respectively.

Table 8. Values of ecosystem services provided by different scenarios in two farms.

	Farm Extension (ha) Involved in the RDP Measurement	**Payments to Farmers Deriving from RDP Measures Adoption (€)**	**Erosion Protection Value (€)**	**Erosion Decrease (%)**	**Water Regulation and Supply Value (€)**	**CO_2 Sequestration (Surface Layer) (€)**	**Biodiversity**	**Fertility Soil Improvement**	**Fuels Use Saving as Avoided CO_2 (€)**
F1 farm									
Scenario T0	189.73	44,850						medium	
Scenario T1	55.09	8264	4451	17	6170	68,312	-	good	319
Scenario T2	157.41	39,354	19,270	74	17,630	395,257	>1.5–4 time number of earthworms	good	913
Scenario T3	179.98	50,940	24,893	95	30,956	451,922	>1.5–4 time number of earthworms	good	1043
F2 farm									
Scenario T0	118.4	27,934						medium	
Scenario T1	31.11	4667	4656	19	3484	38,576	-	good	180
Scenario T2	88.89	22,222	17,747	74	9956	223,203	>1.5–4 time number of earthworms	good	515
Scenario T3	120.16	32,414	22,726	94	20,667	301,712	>1.5–4 time number of earthworms	good	697

	F1 farm	**Scenario T0**	**Scenario T1**	**Scenario T2**	**Scenario T3**	**F2 farm**	**Scenario T0**	**Scenario T1**	**Scenario T2**	**Scenario T3**
Farm Extension (ha) Involved in the RDP Measurement		189.73	55.09	157.41	179.98		118.4	31.11	88.89	120.16
Payments to Farmers Deriving from RDP Measures Adoption (€)		44.85	8264	39,354	50.94		27,934	4667	22,222	32,414
Erosion Protection Value (€)			4451	19,27	24,893			4656	17,747	22,726
Erosion Decrease (%)			17	74	95			19	74	94
Water Regulation and Supply Value (€)			6170	17.63	30,956			3484	9956	20,667
CO2 Sequestration (Surface Layer) (€)			68,312	395,257	451,922			38,576	223,203	301,712
Biodiversity			-	>1.5–4 time number of earthworms	>1.5–4 time number of earthworms			-	>1.5–4 time number of earthworms	>1.5–4 time number of earthworms
Fertility Soil Improvement		medium	good	good	good		medium	good	good	good
Fuels Use Saving as Avoided CO_2 (€)			319	913	1043			180	515	697

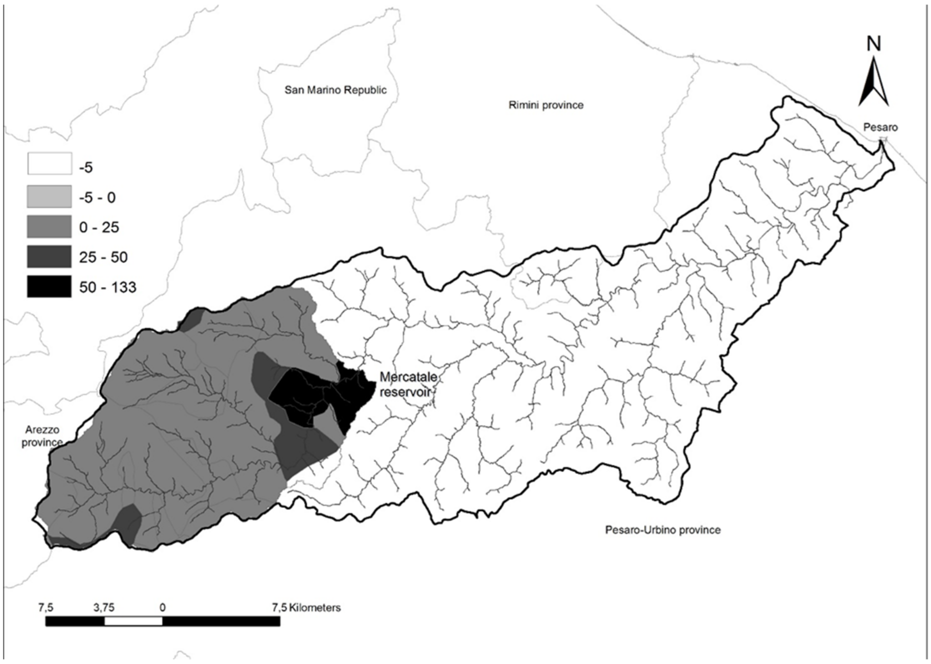

Figure 4. Spatial distribution of N surplus. Units are kg Nha^{-1}/year.

From T0 to T3 scenario, erosion decreased by 17, 74, and 95% for F1, and 19, 74, and 94% for F2, respectively, with a significant erosion decrease in the more conservative scenario at the local scale.

The water regulation and supply service, considering the value of 112 € ha^{-1} (T1 and T2 scenario) and 172 € ha^{-1} (T3), corresponded to € 3484–6170 for the T1 scenario, €9956–17,630 in T2 and €20,667–30,956 for the T3, the more conservative agricultural scenario.

Applying HELPSOIL data to the agricultural measurements provided in the different farming scenarios, we supposed carbon sequestration varies from 68,312–38,576 in T1 to 451,922–301,712 in T3 for F1 and F2, respectively. In addition, data showed a biodiversity increase in the number of earthworms between the traditional agriculture (T0) and the conservative one (T1-T2-T3), and fertility soil improvement from medium to good. Fuels use saving expressed as Kg ha^{-1} of avoided CO_2 is €319–180 in scenario T1 until €697–1043 in more conservative scenario (T3).

5. Discussion

Agricultural systems provide provisioning ESs that are essential to human well-being. Nevertheless, they also provide a range of other ESs, including regulating services and services that support provisioning.

Agricultural management practices are key to realizing the benefits associated with ESs and reducing disservices from agricultural activities applying solutions contained in RDP programs as challenges that will be magnified in the face of climate change. The European Commission aims to invest in NbS as living solutions inspired by, continuously supported by, and, using nature, designed to address various societal challenges in a resource-efficient and adaptable manner and provide simultaneously economic, social, and environmental benefits (European Commission 2015). These solutions can also contribute to the landscape and ecosystem resilience with local-based, resource-efficient, and systematic actions [20]. These solutions are useful in addressing the socio-economic challenges of the 21st century with the primary aim of maintaining and/or increasing welfare production at lower costs. The ecological restoration process—planning, site construction, monitoring, etc.,—generates economic output and employment, forming the "ecological restoration economy" [85].

Considering different RDP actions connected to regulation ecosystem services, we simulated different scenarios at the upper river basin and local scale, with solutions based on ecological functions recovery considering the economic and environmental benefits of restoration, highlighting the potential role of agriculture in developing these actions also through the RDP tools.

The ecological regulatory functions and their services have been evaluated since they are the fundamental and physiological architecture of maintenance and operation of ecosystems and basic gears for the delivery of other services and can be used to estimate the critical use thresholds compared to the other ESs [43–86].

This study analyses selected regulation ecosystem services provided by agroecosystems as erosion protection, water regulation and supply, and N balance in terms of ecological functions and services in different scenarios at the upper river basin and farming scales.

Data show the decrease of soil loss and the increase of erosion protection service provided by collecting conservative agriculture measures from actual state to a final scenario (AAA_bis or T3) both at the upper river basin and farming scales.

Considering spending for consolidation actions in the upstream Foglia river basin for 10 years (1997–2006) as a value of €6 $\times$ 10^6 (Marche Region data bank, Pesaro Urbino Protection of territory Service), the calculated value of erosion protection for 10 years (€3.6 $\times$ 10^6) corresponds to over half of spending for landslide or consolidation interventions. The value of N denitrification provided by buffer strips in the AAA and AAA_bis scenario is over €30,000.

The value of water regulation and supply provided by the most conservative scenario (AAA-bis) is almost 14 $\times$ 10^6, corresponding to half of the spending for flood defense in the period 1991–2007 for the Foglia river basin (Marche Region data bank, Pesaro Urbino Protection of territory Service).

As highlighted by Maes and Jacobs [20], the integration of the actions expressed by these scenarios represents an indication of the opportunities that farmers can implement, especially through cooperation actions (AEA), in which every action was integrated with the others so that the net effect may be evident and effective in the territory.

The synergy achieved through territorial cooperation can have a twofold effect: to improve the overall resilience of the territory by integrating the Water Directive (WFD 2000/60/EC) and the Directive 2007/60/EC on the assessment and management of flood risks, by improving the regulation ESs and on the other side, by identifying the appropriate stakeholders who can recognize the economic weight of the ecosystem regulation functions and related service.

The proposed scenarios in this study are useful for limiting erosion and increasing the water quality in the study area and, in particular, reducing problems concerning the Mercatale reservoir managed by "Consorzio di Bonifica delle Marche" for irrigation and drinking water. These measures can preserve water quality and quantity and reduce siltation on the tributary of the Mercatale reservoir, increasing its useful life. In this context, data derived from this study can be put on the discussion table with some values of ecosystem services supplied by farmers (F1 and F2) in the more conservative scenario (e.g., T3) that could be paid by the "Consorzio di Bonifica delle Marche" stakeholder as buyer of ESs, as highlighted in the PES example of Figure 5.

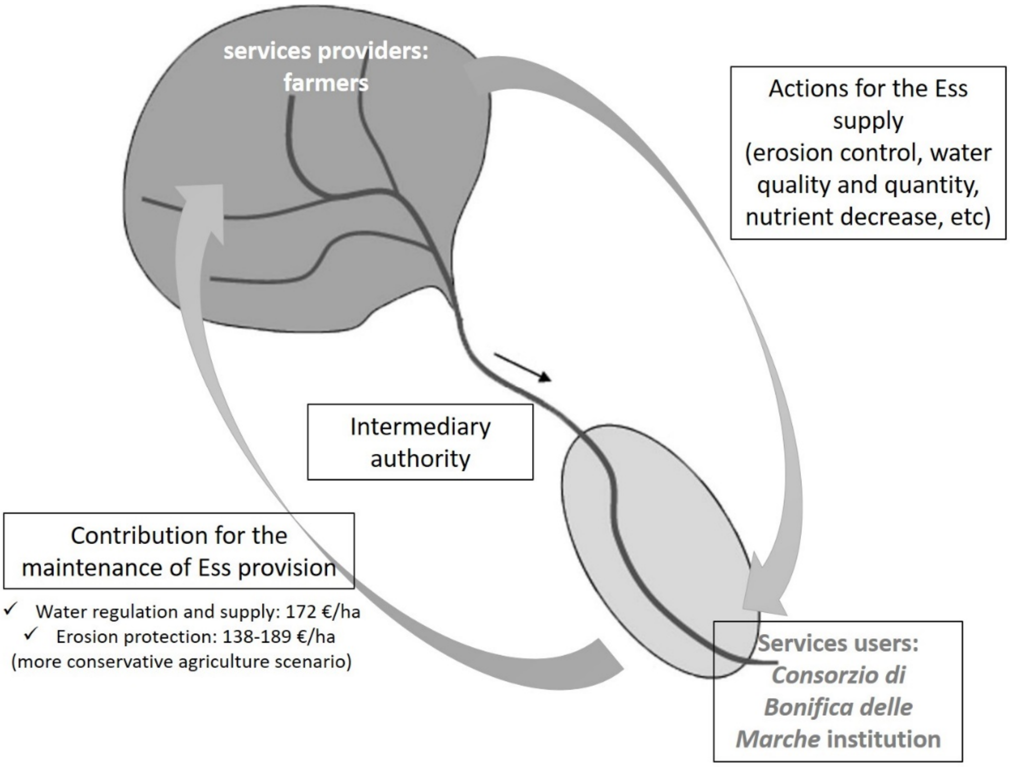

Figure 5. Hypothetic PES scheme (elaborated from Pagiola and Platais [87]) with Ecosystem Services values provided by farmers with actions as proposed in scenario T3.

At the national level, the great scientific debate on ESs and the opportunity to its implementation that generates economic output and employment, which forms the ecological restoration economy, allowed to insert in the national Law n. 221, (dated 28 December 2015) "Environmental provisions to promote green economy measures and to contain excessive use of natural resources", a specific article (no. 70) regarding the PES as a tool to compensate providers of ESs by pricing their values for users.

Furthermore, part of the value of these ecosystem services could be recognized as the cost of the natural resources that water tariffs could absorb for downstream people who use them. Ministerial Decree 39/2015 developed guidelines for defining resource and environmental costs for the different water use sectors at the national level.

These mechanisms can encourage the conservation of natural ecosystems through environmentally-friendly practices to preserve natural resources, thereby also improving the welfare in rural areas [88,89] and at the same time contribute to enriching the debate on ecosystem services provided by actions actuated by farmers.

For this reason, results of these evaluations, based on a stakeholder consultation (Consorzio di Bonifica delle Marche and regional agricultural sector), will be presented to farmers by local agricultural associations considering that farmers' awareness of their role and economic motivation play a central role in terms of developing synergic actions useful to natural capital conservation and in maintaining flows of ecosystem services [36].

Local-scale evaluation considering two different farms further highlights the suitability in terms of employment and economic output multipliers for farmers and farms, especially by agro-environment agreement that emphasizes regulating ESs management and also generating public goods that can be finalized to the PES tool identifying an ES buyer.

The ESs-based approach can be a point of convergence for policies that simultaneously address concerns for food provision and the integration policies of water regulation WFD (2000/60/EC), the Directive 2007/60/EC on the assessment and management of flood risks and biodiversity strategies.

The European Commission [90] advocates an Action Plan that better speeds up the practical implementation of nature protection directives, reversing biodiversity loss and degradation of ESs also concerning resilience to climate change and their mitigation.

For these reasons, the actions that can be implemented by farmers in the new rural development programs (RDP 2023–2027) can be considered as NbS and could positively affect the quantity, quality, and time of some ESs related to water regulation and supply, N adsorption, and erosion protection [91]. These actions can protect, sustainably manage, and restore natural or modified ecosystems, which address societal challenges (e.g., climate change, food and water security, or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits.

6. Conclusions

Agriculture undeniably can be a balanced tool for production and land management in harmony with the Farm to Fork (F2F) strategy, the ten-year plan developed by the European Commission to guide the transition towards a fair, healthy, and respectful food system of the environment. However, a territorial vision and planning of actions are necessary, which, if integrated, can develop emerging properties beneficial for a territory's resilience. The actions of the European agricultural strategy can be grouped within NbS, whose objectives offer solutions to the social challenges that involve working with nature as an integrated approach that could address the twin crises of climate change and biodiversity loss [92].

NbS may involve the conservation or rehabilitation of natural ecosystems and/or the enhancement or creation of natural processes in modified or artificial ecosystems, applied at both micro and macro scales [93]. Therefore, NbS focuses on protecting and restoring ecosystems, increasing functionality, and addressing societal challenges while improving human well-being and biodiversity [94].

The evaluation of ESs, therefore, represents a useful tool for developing different types of actions:

1. Build resilience scenarios to help make informed choices about the most advantageous agricultural practices and to consider these values for sustainable management and monitoring of the territory.
2. Develop synergistic actions so that the territory can offer an effective and lasting response to climate change.
3. Maintain a greater focus on ecosystem services support efforts to emphasize multifunctionality in agriculture, to manage a broader set of ecosystem services, including provisioning, but also cultural services, which rarely have a price on the market, thus highlighting the potential of the role of farmers in a very diverse landscape context.
4. Develop opportunities regarding the payment of ESs as recognition of the maintenance of functions useful to the territory and structures of collective interest, such as—in this case—the Mercatale basin for irrigation purposes.

This approach promotes considerations on the benefits provided by the activities of farmers in the conservation of natural resources and the search for synergies between food production and conservation of the resilient landscape with its ecosystem services by applying some actions of the new community agricultural policy, such as NbS, in harmony with the objectives of the Farm to Fork strategy.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land11010057/s1. Table S1: Detailed data for available water and water stored and released for each land use classes.

Author Contributions: Conceptualization, E.M. and R.S.; methodology, E.M. and R.S.; formal analysis, E.M.; investigation, E.M. and R.S.; data curation, E.M.; writing—original draft preparation, E.M. and R.S.; writing—review and editing, E.M.; project administration, R.S.; funding acquisition, R.S. All authors have read and agreed to the published version of the manuscript.

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