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# The Total Economic Value of Lands with Civic Uses as a Tool for Their Protection and Enhancement: A Case Study in Tuscany

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**Abstract:** This study aims to quantify the economic value of environmental externalities by proposing an approach tailored to areas designated for "civic uses". These areas fall within the broader category of "collective goods" on which the legislator places particular emphasis, especially in regard to their protection and enhancement. The technique applied in this study is the total economic value (TEV), quantified through a spatialization and modeling of socioeconomic and environmental variables on Geographic Information Systems. The methodology was used for a specific case study area, the forests of Land Association "Bosco dei Bardi" in the Tuscany region of central Italy. This area exhibits the same characteristics and fulfills the same functions as those designated for civic uses. The results demonstrate the importance of providing public decision-makers with appropriate tools to protect and enhance these areas. The results also underscore the economic significance of forest ecosystem services compared to average regional values. The study finally confirms that Land Associations present a promising avenue for revitalizing abandoned territories, consistent with civic use objectives.

**Keywords:** agroforestry benefits; civic uses; collective goods; total economic value; Land Associations



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## 1. Introduction

This work fits within the ever-expanding literature on the assessment of the total, market, and nonmarket benefits of agroforestry activities, proposing an original and highly operational approach with a specific application context aimed at areas characterized by "civic uses".

The ability to assess the externalities of such areas, that is, those "utilities" that society recognizes but do not pass through the market, is increasingly important for public decision-makers. This has led to a significant amount of work on evaluating individual functions of areas (particularly forested ones) for specific territorial contexts.

This contribution aims to focus on the so-called "collective goods" since Italian national legislation, particularly since 2017, has placed considerable emphasis on their protection and enhancement. The methodology proposed here is intended to respond to a precise request for functional tools for programming and decision making by the competent authorities.

With the introduction of Law No. 168/2017, the Italian legislator intended to promote the protection of all territories defined as "collective domains". The expression "collective domains, however named" used in the provision suggests a definitional problem that the law itself attempts to resolve as a necessary premise for any intervention affecting these territories.

The root of the multiplicity of cases to which the term "collective domain" can refer lies in the long history, both conceptually and regulatory, of the so-called "civic uses" on certain territorial areas. The term "civic use" itself is considered (probably even by the legislator) misleading because it refers to "lands for collective enjoyment, lands burdened by civic uses, lands of descendants of ancient original families, universal domain, municipal domain, civic domain" [1]. This highlights one of the most significant issues related to the topic at hand, namely, the management of similar situations applied to contexts with different property rights.

Civic uses were first codified in 1927 with Law 1766 and subsequently with its application by Royal Decree 332/1928. This codification was necessary to regulate any disputes arising from assessments for the removal of legal claims or liabilities from private lands, the use of public lands, and the roles of public entities in the matter [2].

Following subsequent legislative interventions[1], Law 168/2017 provides a definition of collective goods in Article 3, identifying them in six cases, all of which contemplate the persistence of civic uses on the territory regardless of the property holder[2]. However, the law goes far beyond the aspect of harmonizing the concept of collective good, defining the specific roles of the public sector concerning what is thus defined. In particular, the two main roles are identified as the "protection" and "enhancement" of these areas. The formalization of these roles highlights the need to create a set of tools available to the public manager that allows for an adequate and precise assessment of intervention priorities. Essentially, a tool is needed to compare the benefits with the costs of possible protection interventions to evaluate their efficiency and/or measure the potential benefit derived from enhancement actions that aim to recover areas that do not fully express their contribution to the community.

It should be noted that Law 168/2017 is neither the first nor the only legislative provision to highlight the importance of enhancing and protecting areas characterized by civic uses, as their environmental value has been emphasized since Law 431/1985 [3] and various interventions by the Constitutional Court [4,5], which highlight, among other things, the connections between environmental value and the responsibility of local authorities.

In recent years, new tools for assessing and controlling the environmental aspects of the areas under analysis have been developed, with particular reference to forests. Many of these experiences are becoming part of the common language used by public administrators and officials. A common feature of many experiences is the processing of information on the state of forests in connection with sustainability goals and the environmental policies of the entities. This way, information and environmental data can be used to verify progress made, and such information is available in environmental accounting systems. However, this information needs to be enriched through economic evaluation methodologies of the ecosystem and the externalities it produces, with the aim of adding to the physical indicators and environmental expenditures a new economic account that translates the benefits and social utility values of these areas into monetary terms.

The methodological approach proposed in this work is, therefore, the estimation of the total economic value (TEV) and its spatialization, which allows the appreciation of the geographical distribution of environmental values and the overlaying of these values with other geographically relevant information. Notoriously, this calculation includes the sum of the use value and the nonuse value of the resource being estimated, where the former depends on the ability to obtain individual benefits by physically interacting with the resource, while the latter relates to the altruistic component of human behavior [6]. In the specific case of evaluating collective goods, it is important to move away from the confusion that can be generated by the term "civic uses" to describe the value components of the goods to be estimated. Although the meaning of the term, which makes its use value evident, is widely consolidated (and defined by law[3]), it should not be overlooked that the legislator intended to include within this concept the value components enshrined in the Constitution related to social and environmental aspects [1], and, thus, typically nonuse.

The importance of evaluating the nonuse value becomes even more significant when considering the categories of individuals who can benefit from the services produced by the areas under examination. Indeed, although the benefits of agro-forestry and pastoral services (mushroom picking, woodcutting, hunting, fishing, grazing, etc.) are explicitly directed at well-identifiable and delimited local communities, the maintenance of civic uses in the territories generates a valorization of positive externalities (the hydrogeological function, protection from climate change. . . ) that have a spillover effect on the entire community. This is also legally confirmed in Germanò's analysis of the connection between civic lands, civic uses, and the concept of *utilitates* [1], which refers to "not only modest economic utilities [. . . ] but also the most varied and in any case all utilities, so that the entire economic value of the good remains (and remains) absorbed in them".

The need to perfect an adequate evaluation method is all the greater the more one observes the relevance of the areas affected by civic uses on the national territory: to the estimated three million hectares [7], one can add, with a view to recovery and enhancement, the areas currently abandoned but which, due to their characteristics, can potentially provide the community with the same types of civic services. This goes well beyond the 1.2 million hectares of collective properties measured with the 2020 ISTAT Census [8], highlighting, once more, the vastness of this issue. The areas currently identified as subject to civic uses also generate and suffer from a series of specific issues: on the one hand, they can give rise to complexities in their administration or, for example, in managing building issues on them, while on the other, they suffer from the constant lack of public resources that can be allocated to them and the constant erosion by advancing urbanization [2], which, among other things, directly compromises their main legally recognized functions, namely, agro-forestry and pastoral.

Within the territories subject to civic uses, we have also included the Land Associations, which represent different forms of management of rural agroforestry land, with many points of contact with civic uses. The Land Associations offer a valid and new perspective for the enhancement of territories undergoing abandonment, through management models that can be entirely assimilated to those currently existing for civic uses. Our work concerns a case study related to the territory of the Land Association "Bosco dei Bardi", located in the Province of Prato (Tuscany, central Italy).

In light of what has been presented, this work seeks to underscore with concrete results the importance of evaluating territories subject to land association and/or civic uses with appropriate tools to provide the essential informational basis for public decision-makers, aiming at their use for the protection and enhancement of these areas as required by law. Specifically, through a case study employing the TEV approach, it is highlighted how this method represents a valid tool for the territories in question.

## 2. Methodology and Study Area

In Italy, the structure of territories subject to collective domains is characterized by a predominant presence of forests. As a result, the assessment of the various use and nonuse functions of these areas is directly related to the presence or absence of forests. The proposed economic evaluation methodologies allow us to supplement the physical indicators of the ecosystem and its externalities with a monetary evaluation of the benefits and social utility values produced by the forest.

Different methodologies for evaluating the environmental benefits provided by the forest allow the use of well-documented results in the literature relevant to the territory under study to estimate their TEV. It is well known that this value is closely linked to the ecological, geomorphological, and geographical characteristics of the vegetation, while many methods for evaluating environmental benefits are not georeferenced and refer to large forest and territorial areas.

Given that the focus of the research is to attribute economic values to specific areas of the territory, it was deemed appropriate to use techniques to spatialize the TEV [9–11]. The approaches examined ranged from benefit transfer [12,13] procedures to meta-analysis models capable of incorporating geographical variables. However, these models have some limitations in the spatial disaggregation of values when it is necessary to include socioeconomic variables, which are generally available on a minimal spatial scale. The so-called "spatialization" of social utility value, which has appeared in the most recent international literature, allows the appreciation of the geographical distribution of environmental values and the overlaying of other relevant geographical information onto these values.

In some cases, the estimation of the economic value of certain forest functions analyzed was derived from the application of already spatialized data, while in other cases, it was the use of spatialization methodology itself that enabled the determination of the economic value of a specific forest function. Spatialization techniques were also applied to some of the forest functions whose economic value was known for large forest and territorial areas but not how this could vary in relation to the ecological, geomorphological, and geographical characteristics of the vegetation [14].

Consequently, the choice fell on this latter methodological approach, which allowed for the optimal use of all available data to improve forest planning tools, utilizing the wealth of knowledge already at our disposal.

### *2.1. The Value of Environmental Resources*

Initially, it is useful to remember that economic goods can be classified based on two general principles: rivalry and excludability in use. The concept of rivalry is based on the principle that the consumption of a good by one individual compromises or does not compromise its existence (absolute rivalry, private good; no rivalry, public good). It is important to note that rivalry in consumption should not be considered in a "strictly physical sense, but should be related to the relationship between the quantity used in a given time period and the overall availability of the resource" [6].

Excludability expresses the possibility of using a good exclusively or nonexclusively by the holder. Goods with no excludability are defined as public goods, while those with absolute excludability are defined as private goods. Therefore, a good with absolute rivalry and excludability is defined as a pure private good, while a good with no rivalry and excludability is defined as a pure public good. Due to the lack of rivalry, the demand for a good will be satisfied by its mere existence, with the cost incurred for each additional user being null (marginal cost). This implies that no individual, acting as a private entity, will want to undertake the production of goods for public consumption, as they cannot derive economic benefits from it: "the production of such goods will therefore be the prerogative of the public operator, who will allocate the cost, for example, through fiscal measures" [15]. The forest is particularly configured as a mixed good, simultaneously presenting characteristics of both public and private goods. The private component (which generally coincides with timber production) pertains to the owner, while the public component is represented by all the positive externalities generated by a forest stand, from which the community benefits. This aspect is precisely what we seek to explore further to understand how the enhancement of collective domains can contribute to the development of all the public functions they serve. Environmental economic theory postulates that "a change in the quality or provision of natural resources can have a significant impact on the quality of life and the wellbeing of individuals in a society" [16], and, consequently, the persistence of collective domains on territories can, in turn, contribute to an increase in wellbeing as an instrument for the environmental protection of the territories they encompass. The magnitude of these changes can be measured in monetary terms since money represents a measure of the utility an individual attributes to goods and services that affect their wellbeing. The attribution of value to environmental goods is based on the measurement of the willingness to pay (WTP) in circumstances where markets fail to reveal this information [17]; methodologically, this is possible through the estimation of WTP (or in other cases, willingness to accept—WTA), a given amount of income for a change in individual wellbeing, resulting from a qualitative or quantitative change in the availability of the environmental good or service itself. From an estimative point of view, the economic evaluation of the social functions performed by forests, conducted from a public perspective, does not always allow for the use of fundamental estimation criteria. The public perspective mandates that the use of evaluation approaches follows the methodological guidelines of cost–benefit analysis concerning the pricing system used, the choice of the discount rate, and the costs and benefits to be considered. Therefore, it became necessary to introduce an estimation criterion that would allow for the evaluation not of market value, but the use and nonuse values of the goods under consideration. These motivations led valuation experts to identify an additional economic aspect, the economic aspect of social utility value [18,19]. With the introduction of the most probable social utility value in the field of valuation, the perspective of evaluation radically changes, shifting from a private view of the goods under consideration to a consideration of the collective interests. The social utility value, in fact, concerns "the value attributed by the community to a good, expressed as the sum of the individual utilities of those who have an interest in it" [19]. Operationally, to perform the evaluation of social utility, it is necessary to estimate the demand function for the good by the community, relative to the multiple functions it can provide. The value of the good under estimation will, therefore, be given by the area under the demand function, which will simultaneously represent the consumers' utility and their willingness to pay or rent, in cases where no cost is incurred by them to access the good (a situation that occurs, for example, for public services provided by the forest and the environment).

The objective of our research is to assign value to those utilities referred to by Germanò [1] that are comparable to all nonmarket functions inherent in the concept of environmental goods, characterized by the absence of a market and not being subject to exclusive property rights. Therefore, it is possible to use monetary methodologies in use for the estimation of the TEV also for the evaluation of collective domains. These methodologies can be attributed to direct methods (contingent valuation or choice modelling techniques) or indirect methods (cost value, hedonic pricing method, and travel cost method).

### *2.2. Spatial Analysis of Forest Functions*

The application of benefit transfer procedures was the first attempt to address the problem of spatializing social utility values with high resolution. Eade and Moran [9], Lovett et al. [10], and Bateman et al. [11] were the first to propose and apply procedures that use Geographic Information Systems (GIS) to spatially model the transfer of environmental values. The most advanced applications are based on meta-analysis approaches to incorporate geographic variables into the model [12,13]. The need to consider socioeconomic variables, generally available on a minimum spatial scale of census units (e.g., municipality), has limited the spatial disaggregation of values.

Expert systems, cost–benefit analyses, and decision support systems (to name a few examples) in recent applications [20] can assign a cardinal index of georeferenced and diversified evaluation with high resolution based on forest characteristics. However, this evaluation is not usable where monetary units are required, such as in cost–benefit analysis, environmental damage assessment, or for many public spending allocation decisions. Moreover, such methods often rely on empirical–subjective bases without explicitly stating the uncertainty associated with these evaluations.

Recently, the international literature has increasingly focused on the so-called "spatialization" of social utility value [21]. Spatial disaggregation allows for appreciating the geographical distribution of environmental values and overlaying these values with other relevant geographic information [22].

The main feature of the proposed methodology is the creation of a high-resolution geographic dataset to be used for ex-ante and ex-post cost–benefit analysis to improve forest planning. The geographic data used for the evaluation were as follows:

- Forest areas extracted from the Corine Land Cover map;
- Geodatabase of community, national, regional, and local protected areas;
- Road network (i.e., the linear geometric components of the regional road and communication network promoted by the Tuscany Region);
- Digital terrain model (DTM) of Tuscany;
- National Ecological Network [23];
- Rete Natura 2000 Geodatabase[4];
- Geolithological map of Tuscany, part of the numerical data archive of the Tuscany Region, acquired in 1993.

The geographic dataset used in this study is based on the work conducted by Bernetti et al. [24] for calculating the TEV of forests in the Tuscany region. The data and results from that territorial information system were applied here to calculate the TEV for the study area.

The geodatabases were organized according to a spatial grid model with a side of 100 m, allowing for satisfactory spatial resolution.

The following sections will illustrate the methodologies for the spatialization of the annual TEV of the forests in the investigated area. The economic value of forest functions was derived from the application of already spatialized data (for details see [14,24]). For the overall TEV estimation, each forest function was assessed as follows.

Recreation in protected areas

The travel cost method (TCM) was applied to estimate the value of recreation in protected areas. The TCM was applied to both tourists and day visitors, initially differentiating the two categories based on the distance to be covered to reach the forest area of reference. The systematic application of this procedure to all parks and protected areas required identifying a method for estimating individual demand functions, considering environmental and infrastructural peculiarities as well as the socioeconomic characteristics of individuals forming the so-called catchment area of each protected area. For this purpose, the probabilistic choice model with stochastic utility developed by Ferrini [25] for protected areas in Tuscany was used.

Hunting activity

The overall value of hunting activity for regional agroforestry resources was calculated by transferring the results of known studies in the literature on the WTP per hunter per year [26]. The average WTP was multiplied by the number of active hunters in Tuscany, obtaining a total social utility value of hunting activity. The spatialization of this value was realized proportionally to the ecological suitability of the species of hunting interest, calculated by aggregating the geodatabases created as part of the National Ecological Network project [23], according to a relation in which the hunting value per hectare per year for each area is proportional to the ecological suitability of the species of hunting interest [24].

Mushrooming

The first phase of the evaluation involved identifying the total social utility value for the entire region. The economic value of mushroom picking was quantified for all protected areas where this activity is permitted by regional regulations. Methodologically, this function might face the problem of partial overlap with the recreational–tourism value. However, analysis of the referenced works indicated that this limitation was not restrictive, as respondents verifying the recreational value did not engage in mushroom picking; additionally, the two activities are generally performed in different seasons and under different conditions. Data reported in the literature [27] revealed the number of mushroom pickers in Tuscany and the maximum cost of the picking permit. The choice to use the maximum permit value arose from the consideration that, in the absence of estimates on the willingness to pay for mushroom picking, the maximum permit value for nonresidents constitutes a good approximation. The spatialization was performed based on a fuzzy suitability map for the different species of Boletus mushrooms picked in Tuscany, created through the methodological approach of identifying the ecological niche. The fuzzy functions used included the following:

- Forest type;
- Geomorphology;
- Climate: autumn rainfall, spring rainfall, summer rainfall, annual average temperature, summer average temperature, and autumn average temperature.

Naturalistic value

The naturalistic value was estimated as a "nonuse" value [28–30], linked to ethical motivations, and in the context of contingent valuation, such value cannot be recorded with high-resolution spatial reference. However, landscape ecology and spatial ecology disciplines have shown that the naturalistic–environmental aspects of a forest cover can be evaluated based on numerous indicators that account for the effects of geographic characteristics related to each location (for a review, see [31,32]).

The proposed methodology is based on the following assumptions:

- In the absence of specific regional studies, studies conducted and known in the literature at the national level on the WTP for the conservation of forest biodiversity were used;
- Such individual WTP is attributed indiscriminately to all regional forest resources;
- The existence value per hectare as a function of the ecological and geomorphological characteristics of the location itself and its geographic surroundings.

Following the methodological reference proposed in Ten Brink et al. [29], the naturalistic value of forest resources is decomposed into the following taxonomy: (i) biodiversity value; (ii) ecological value; (iii) value attributed to endangered species [24].

Value of flow control

This value was estimated based on the substitution cost in the absence of the forest, particularly relying on the estimate of the cost to implement hydraulic works necessary to replace the regulation of peak flows in the absence of the forest. In addition to direct methods, commonly used approaches include the value of cost related to the prevention of damages from calamitous events and the substitution value calculated concerning the works necessary to compensate for the effect of forest surface. The choice was made to use the substitution cost due to its easier and broader applicability on a regional scale. At the methodological level, for each basin, the surface outflows "with" and "without" forest for exceptional events were considered, as recorded by the meteorological station network of the Regional Agency for Agriculture Development and Innovation. The design maximum size of an expansion reservoir system in flood-prone areas was considered, sufficient to allow the discharge of the flow difference due to the forest. The total annualized cost (expropriation, construction, maintenance, and lost income) for the implementation of the reservoir system was determined. Finally, the total substitution cost was attributed to each pixel in proportion to the quantity of water regulated by the presence of the forest.

Drinking water service

The starting hypothesis was to consider the best alternative to groundwater as the water reserves stored in artificial basins and the consequent contribution that forest soils can make to drinking water production based on the water balance. The values of water storage in the hydrographic basins in Tuscany were identified based on known data in the literature. In this case as well, the values were estimated for each individual pixel, and their sum allowed the overall value of this component of the VET to be identified. The estimation process took place in two phases. In the first phase, the water balance of a single location of forest of 1 hectare was calculated using the so-called inverse water balance method [33]. Subsequently, the substitution price per cubic meter estimated on the basis of a review of the social utility assessment applications of the groundwater recharge service was applied [34].

Wood production

The income value of wood production was calculated by annualizing the capital value of the forest stand obtained based on the classic Faustmann formula [35]. The value was estimated based on the assortments of timber products that can be extracted from the forests of the reference area, depending on the production processes and silvicultural and utilization practices consolidated in the area, as well as based on the prices observed on the internal market. To this end, not only ecological characteristics (increments, type of wood species, etc.) but also technical variables (type of machinery used, etc.), logistical variables (organization of the production site, distance from timber sales centers, etc.), and economic variables (hourly productivity, machine costs, etc.) were considered based on the methodology reported in Bernetti et al. [24].

Carbon value

The function of climate change mitigation can be quantified through the activity of carbon fixation stored in trees and not released into the atmosphere, contributing to the reduction in greenhouse gas emissions, particularly carbon dioxide ($CO_2$), in accordance with the Kyoto Protocol guidelines. Considering that carbon dioxide sequestration refers to the annual amount of $CO_2$ accumulated in the aboveground and belowground mass of the plant, the sequestered quantity depends on growth and mortality, which in turn depend on the species, age, structure, and health status of the forest. The annual benefits in terms of $CO_2$ fixation can be quantified by considering the annual increments of various species considering the woody mass transformed into biomass expansion factor (BEF) subsequently multiplied by the carbon price [36].

### *2.3. Study Area*

The study area is the Land Association "Bosco dei Bardi" located in the Province of Prato (Tuscany, central Italy). This specific area was chosen as it was suitable to apply, as mentioned in the previous paragraph, a geographical dataset based on the work of Bernetti et al. [24]. Although it exclusively represents a forest area, this is intended as a first step of a study that eventually will extend to agroforestry and other natural (e.g., aquatic) ecosystems and territories.

The area reaches a total surface of about 92 ha (Figure 1). The altitude is in the range 213–1074 m a.s.l with an average value of 492 m a.s.l. From a climatic perspective, the area experiences an average annual temperature of 12 °C, with average minimum and maximum temperatures of 8 °C and 16.3 °C, respectively. July and August are the hottest months, with an average temperature of 21.8 °C. The region receives an average 85 rainy days per year, with a total annual rainfall of 873 mm.

The fauna of the area is highly diverse, largely due to the early abandonment of mountain agricultural activities by humans, which allowed forests to reclaim the land beginning in the early 1900s. Wolves were first documented in the region during the early 2000s. Roe deer, wild boars, and deer were reintroduced starting in the 1950s. The area also hosts a variety of mammals, including numerous mustelids such as pine martens, beech martens, skunks, and badgers. Additionally, the presence of the wildcat has been documented in the region.

The territory is mainly covered by woodland with a forest index equal to 90% (the value arises to 94% if areas with evolving woodland and shrubby vegetation are included). Broadleaved forests are the most widespread category (88%), followed by mixed (10%) and conifers forest (2%). The association is a nonprofit organization and groups together the owners of land for agricultural, forestry, or pastoral purposes. The association's aim is the exploitation and maintenance of the territory, with the specific aim of enhancing the land in the area, avoiding its progressive abandonment, and of protecting and improving the territory and the environment. With the aim of improving the funds and their usability, the association carries out actions aimed at maintaining local roads, inter-farm roads and paths, actions necessary for hydrogeological safety and the prevention of forest fires and, in general, all actions aimed at improving of the productive potential of the land. The association, also in collaboration with the Municipalities in whose territories the donated land is located, promotes social initiatives aimed at involving citizens, schools, and third-sector associations.

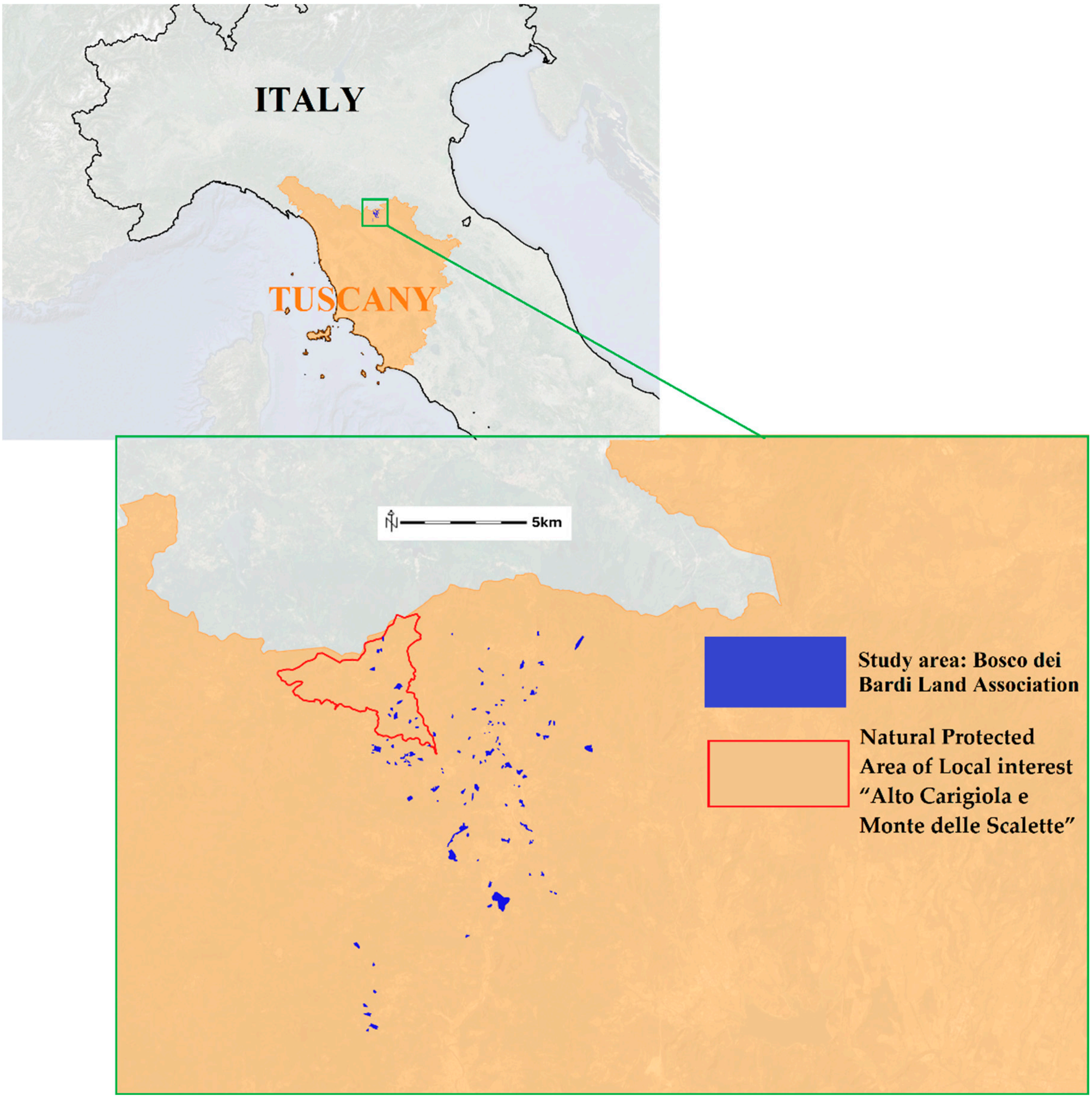


**Figure 1.** Localization of study area.

## 3. Results

The total value of the single forest ecosystem service (FES) was calculated for every forest compartment of Bosco dei Bardi Land Association through a map overlay on GIS. The overlay was based on both the raster map of each FES annual value—developed by Bernetti et al. [24] as described in Section 2.2—and a vectorial map (polygons) representing the boundaries of Bosco dei Bardi forest compartments (as shown in Figures 2–4). The total annual value for the entire study area (EUR/year) was calculated by summing the pixel values for each FES within the territory. The unit value was quantified as the total annual value per unit of surface area (EUR/ha year$^{-1}$).

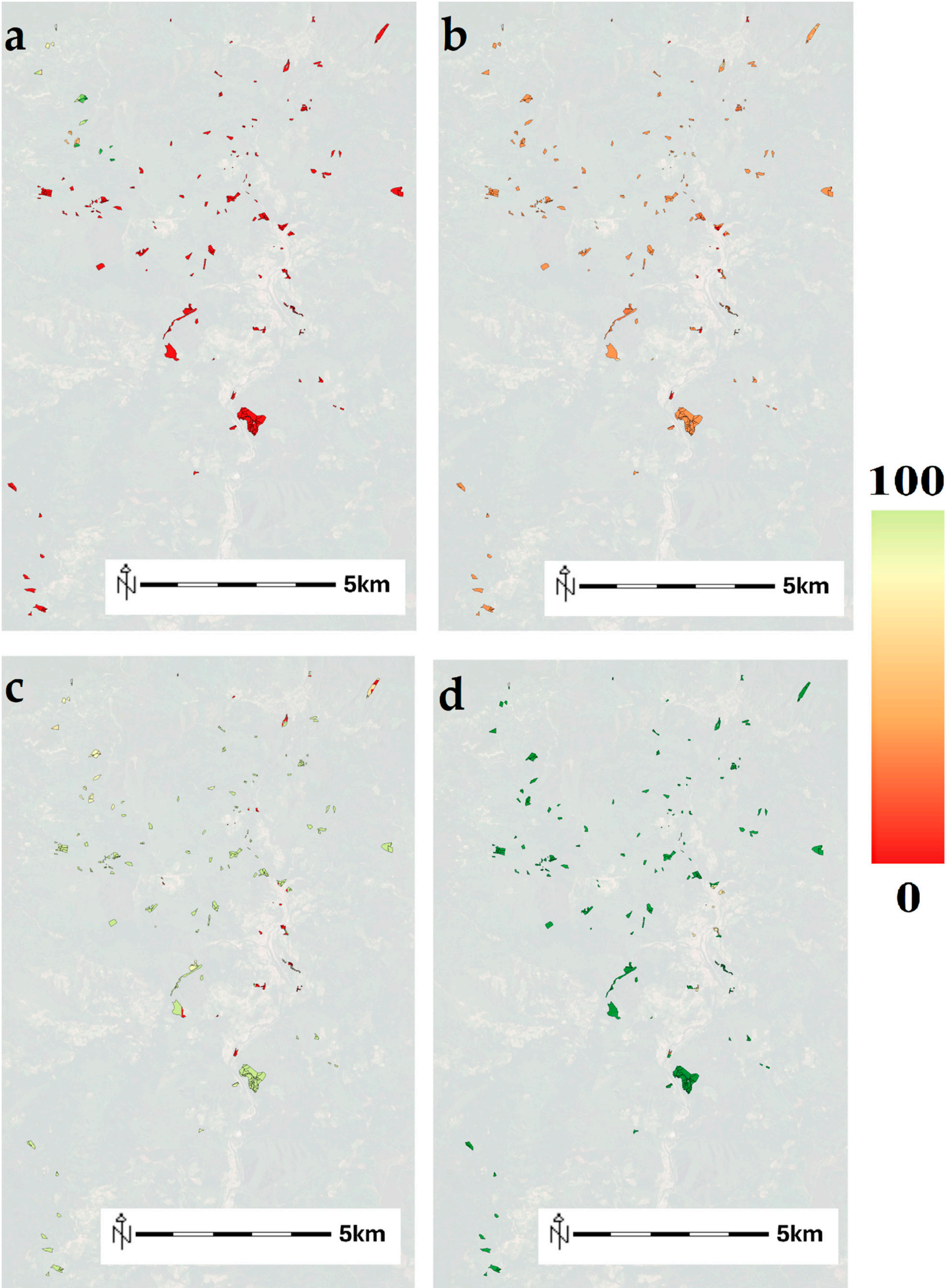


**Figure 2.** Forest ecosystem services value: (**a**) recreation in protected areas, (**b**) hunting activity, (**c**) mushrooming, (**d**) naturalistic value (U.M.: EUR/ha $y^{-1}$).

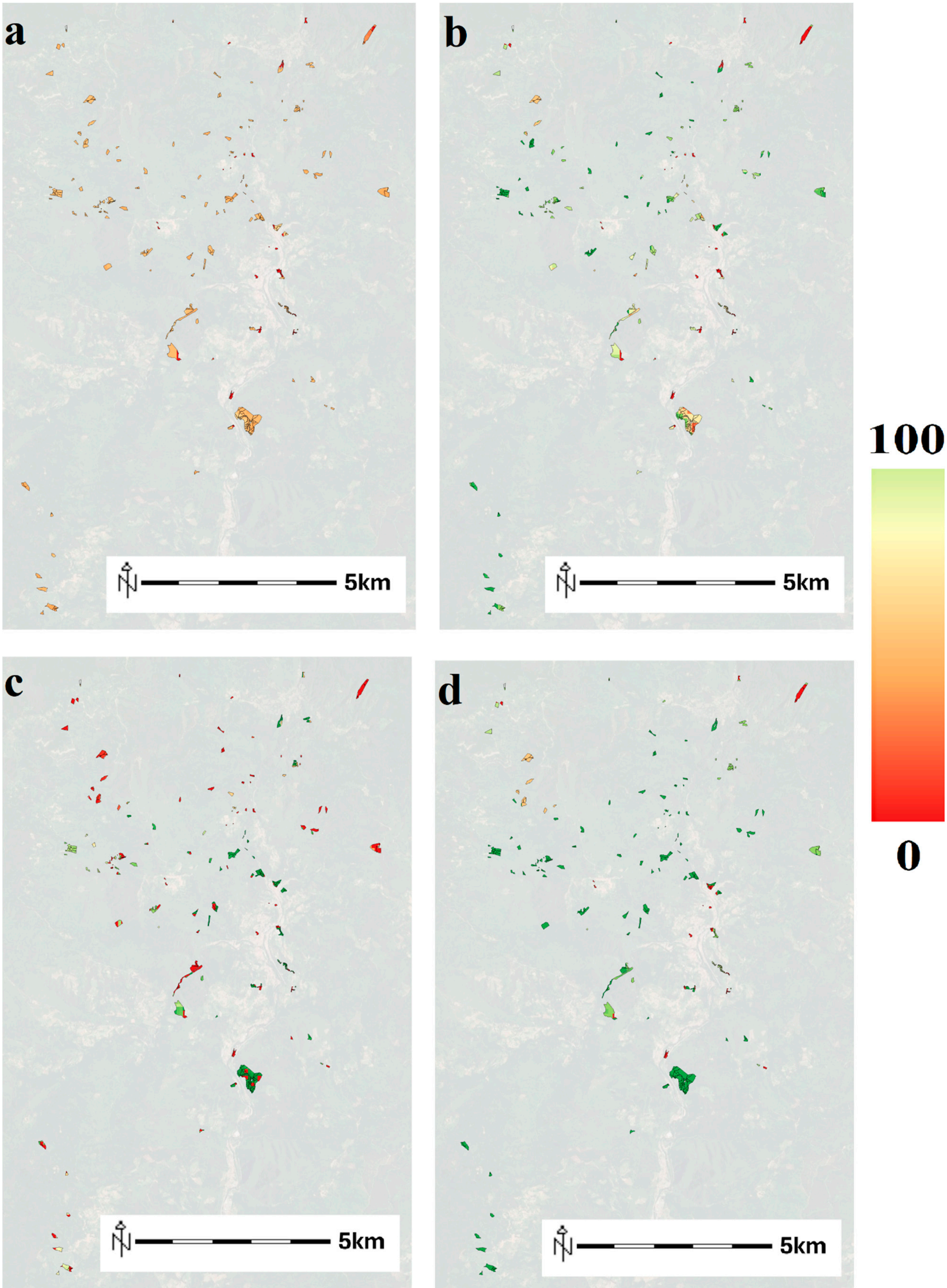


**Figure 3.** Forest ecosystem services value: (**a**) water flow control, (**b**) drinking water service, (**c**) wood production, (**d**) carbon value (U.M.: EUR/ha $y^{-1}$).

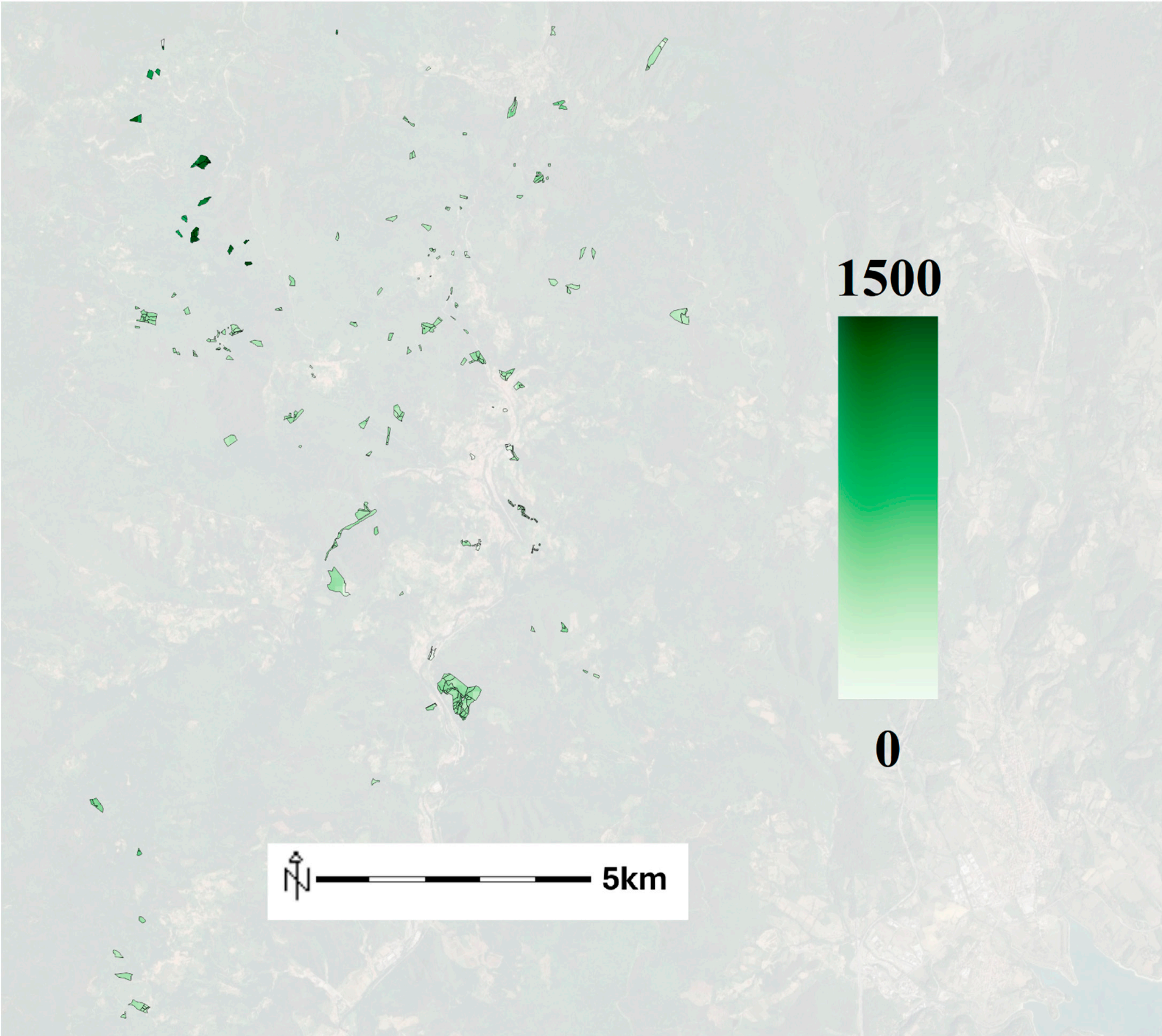


**Figure 4.** Total economic value of forest ecosystem services (U.M.: EUR/ha $y^{-1}$).

Results are reported on Table 1.

**Table 1.** Monetary value of forest ecosystem services for the study area.

| Forest Ecosystem Service | Total Value (EUR/year) | Unitary Value (EUR/ha year$^{-1}$) |
|---|---|---|
| Recreation in protected areas | 7383 | 80.12 |
| Hunting activity | 1916 | 20.79 |
| Mushrooming | 5058 | 54.89 |
| Naturalistic value | 13,797 | 149.72 |
| Water flow control | 2522 | 27.37 |
| Drinking water service | 6940 | 75.31 |
| Wood production | 5113 | 55.48 |
| Carbon value | 7205 | 78.18 |
| **Total Economic Value** | **49,934** | **541.85** |

The TEV is about EUR 50,000/y with a prominent relevance of naturalistic value (27.6%) followed by recreation in protected areas (14.8%), carbon value (14.4%), and drinking water service (13.9%). Hunting activity and water flow control seem to have a lower economic impact on forest based on TEV (respectively, 3.8% and 5.1%).

Focusing on unitary value per surface (EUR/ha $y^{-1}$), the comparison between Bosco dei Bardi area and regional (Tuscany) data [24] reveals how local forests reach a relevant importance for mushrooming (EUR 55 vs. 32/ha $y^{-1}$), naturalistic value (EUR 150 vs. 105/ha $y^{-1}$), drinking water service (EUR 75 vs. 49/ha $y^{-1}$), wood production (EUR 55 vs. 44/ha $y^{-1}$), and carbon value (EUR 78 vs. 60/ha $y^{-1}$); similar values are highlighted for hunting activity and water flow control in the two territorial contexts. Therefore, outputs stress an average high economic level for both market as well as nonmarket FESs with respect to regional area.

Spatial analysis allows us to explicit the localization of results. Figures 2 and 3 show how the monetary values of FESs are mainly widespread in the whole Bosco dei Bardi area. However, some functions report large areas with very low or zero value. Recreation value is concentrated in the northwestern part of Land Association due to the presence of the natural protected area of local interest "Alto Carigiola e Monte delle Scalette". Wood production is also limited to some compartments (with respect to other FESs) probably due to the negative stumpage value obtainable in very steep and/or far away from forest/main roads area.

However, as demonstrated by Figure 4, the TEV of FESs is distributed in the whole area, allowing for a valorization of each compartment.

As reported in the boxplots of Figure 5, a certain variability of FESs in the study area is limited to some functions such as naturalistic value, drinking water service, wood production, and carbon value. Other values have a more constrained range; in particular, the concentration of protected area in a limited surface leads to a very low median value of recreation function.

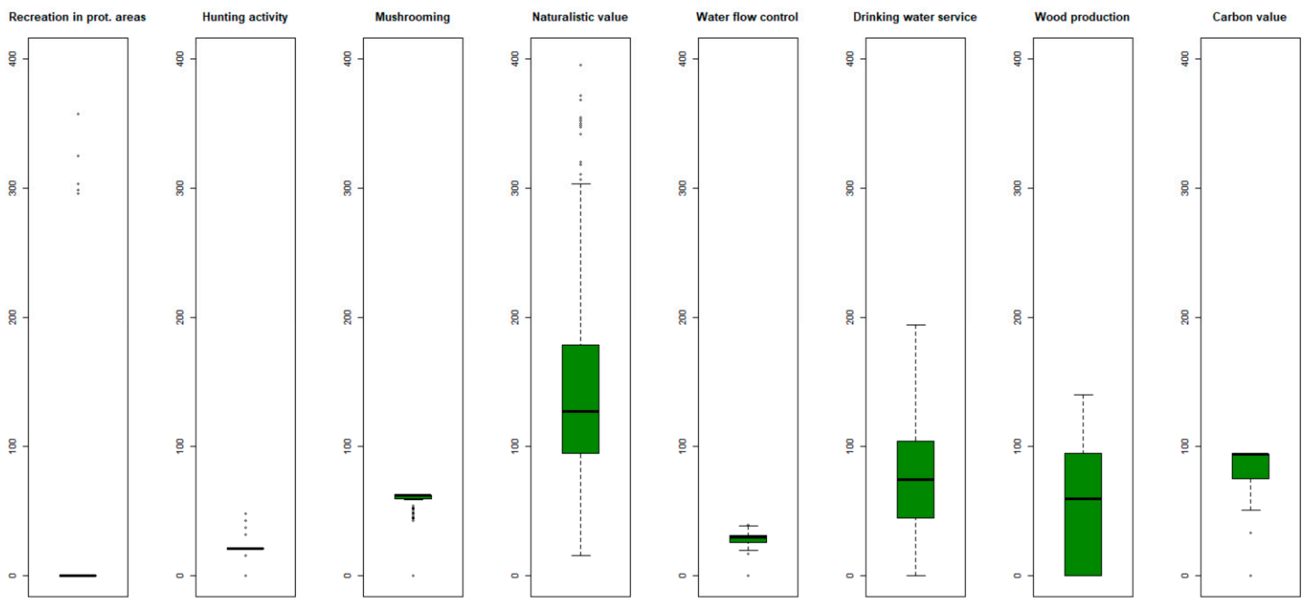


**Figure 5.** Distribution of forest ecosystem services value by pixel on raster map (resolution 100 m × 100 m) (U.M.: EUR/ha $y^{-1}$).

## 4. Discussion

The results that emerged in the study area highlight a high naturalistic value accompanied by a significance of the total economic value (TEV) in each examined forest compartment. The differentiation and importance of the monetary value of the various FESs implies the possibility of also economic valorization of the resources through already established markets, but also thanks to the implementation of new supply chains connected to nonuse values. From this perspective, payments for ecosystem services can represent a valid form of remuneration for forestry externalities, as also indicated by the recent legislation concerning nonproductive investments with environmental purposes (see, e.g., the new Complement for rural development 2023–2027 of the Tuscany region).

GIS representation and association of FES values with forest compartments favor results analysis by stakeholders. This can also help in the potential planning and management with the goal of market products and externalities valorization. This approach allows for quantification of TEV in forested area, in line with several scientific works [37–39].

The adoption of a territorial approach to economic evaluation proves to be highly beneficial as it allows for the acquisition of more precise data. These data can be used both as a repository of estimated benefits and in terms of examined spatial sustainability, as well as facilitating the introduction of the concept of natural capital into environmental decision-making processes. The databases created enable the calculation of several aggregate indices of social efficiency of public spending by the regional authority. For example, cost–benefit analysis of public spending can be evaluated for several macro-categories of interventions such as firefighting services, hydrogeological regulation, maintenance of forestry heritage, or phytosanitary defense. As shown in other research, the value produced by Tuscan forests is often multiple times, sometimes several dozen times, the annual expenditure on public forestry interventions, and this value increases even more when related to interventions for the enhancement, conservation, and promotion of regional protected areas. The most useful aspect of spatialization approaches is the ability to precisely map the benefits produced onto the territory, thereby enabling a better and more efficient allocation of investments.

Another aspect of the case study focuses on the analysis of the use and nonuse value of natural resources within the context of land associations and civic uses. It is interesting to note that in these areas, the nonuse values of the analyzed functions are significant and often exceed the regional (Tuscan) average.

The dataset used to quantify the forest's TEV in the study area is based on the work of Bernetti et al. [24]. A potential future improvement to our quantification could involve updating the geodata used in the research to account for changes in individual variables (although there may have been minor modifications in forest land use in recent years, they are considered acceptable for the purposes of this study).

Further enhancements to the analysis could include quantifying the perceived historical value of common properties and civic uses. Incorporating the subjective perceptions of local inhabitants could provide a more comprehensive TEV of the forest. Another important improvement would be analyzing potential trade-off and conflicts among FESs under different resource management strategies [40,41].

While the current study focuses on forested areas within the collective territory, future research should extend the economic analysis to other rural and natural systems, such as grasslands, shrublands, and aquatic ecosystems. Moreover, applying the method to other contexts could lead to more relevant and in-depth evaluations, further validating the method itself.

## 5. Conclusions

Land associations and civic uses represent different forms of agroforestry land management with a common goal: to manage private or public resources in a way that benefits the community and enhances social uses. In distinguishing between the use value and nonuse value of natural resources, the maintenance of the former often leads to the enhancement and integration of positive externalities. The underlying hypothesis of this work, supported by the extensive literature, is that exercising rights related to civic use or resource utilization (e.g., firewood) and/or maintenance of the land results in environmental improvements. These improvements are linked to the mitigation of negative effects, such as biotic and abiotic/climatic extreme events (e.g., fires, hydrogeological instability, insect damages etc.).

The valorization of nonproduction FESs, such as regulation, cultural preservation, or habitat and biodiversity maintenance, also creates opportunities to sustainably exploit local resources like firewood, mushrooms, or fruits. This can be facilitated, for example, by improving forest roads and trails.

The widespread presence of associations and civic uses in the Tuscan territory (currently being defined) and the possibility of extending their function to also include the enhancement of the utilities cited by Germanò as nonuse functions necessitates a careful evaluation of the benefits produced. This is essential to understand how much to invest in these areas to promote active management, which would prevent the abandonment of these territories, thereby providing benefits in terms of wildfire prevention and extinction, hydrogeological regulation, and combating climate change. Equally important is the analysis of the indirect and induced effects that the resumption of economic activity may entail, which would deserve further future investigation.

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## Notes

[1] Law 431/1985, "Cultural Heritage and Landscape Code" approved by Legislative Decree 42/2004.

[2] (a) Lands originally owned collectively by all the inhabitants of a municipality or a hamlet, attributed to or possessed by municipalities, hamlets, or agrarian associations of any name; (b) lands, with the relevant constructions, assigned in collective ownership to the inhabitants of a municipality or a hamlet, following the liquidation of civic use rights and any other rights of common enjoyment exercised on lands of public and private entities; (c) lands resulting from: the dissolution of common lands as per Article 8 of Law No. 1766 of 16 June 1927; settlements in matters regulated by the aforementioned Law No. 1766 of 1927; the dissolution of agrarian associations; the acquisition of lands under Article 22 of the same Law No. 1766 of 1927 and Article 9 of Law No. 1102 of 3 December 1971; operations and provisions for liquidation or extinction of civic uses; exchanges or donations; (d) lands owned by public or private entities on which the residents of the municipality or hamlet exercise civic uses not yet liquidated; (e) collective lands, of any name, belonging to families descended from the ancient original inhabitants of the place, as well as collective lands governed by Articles 34 of Law No. 991 of 25 July 1952, 10 and 11 of Law No. 1102 of 3 December 1971, and 3 of Law No. 97 of 31 January 1994; (f) water bodies on which the residents of the municipality or hamlet exercise civic uses.

[3] "The legal regime of the assets referred to in paragraph 1 remains that of inalienability, indivisibility, unacquirability by prescription, and perpetual agro-silvo-pastoral use." L. 168/2017, art. 3, paragraph 3.

[4] European Community Directive 92/43/EEC "Habitat", known as "Natura 2000 Network", aims to safeguard biodiversity through the conservation of natural and semi-natural habitats, as well as wild flora and fauna.

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