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Combining Multifunctionality and Ecosystem Services into a Win-Win Solution. The Case Study of the Serchio River Basin (Tuscany—Italy)

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Abstract: Post-war development—characterized by intensive processes of urbanization, concentration of agriculture on the most fertile lands, and abandonment of mountainous and marginal areas—brought about negative environmental and socio-economic consequences. They have been particularly severe in terms of increase of hydrogeological risk, which is high in most Italian regions. Over time, there has been an increasing awareness of the multiple functions played by agriculture in terms of provision of Ecosystem Services (ES), which contribute fundamentally to human well-being. In particular, some ES provided by farmers may help to reduce the hydrogeological risk of territories prone to landslides and floods. In this framework, the paper presents as a case study the project "Farmers as Custodians of a Territory." This project was implemented in the Serchio River basin, Tuscany (Italy), and combines a multifunctional farm strategy of diversification with the provision of Ecosystem Services related to the hydraulic and hydrogeological protection of the river-basin territory. Although this case study should be read within the framework of the theories of agricultural multifunctionality and ES provision, it nevertheless took a very pragmatic and innovative approach, which differentiates it from most of the case studies given in the literature. Results of our analysis show that, by involving farmers as custodians of the territory, it is possible to reach a "win-win" solution characterized, on the one hand, by better services for the community at a lower cost for the Land Reclamation Consortia involved with hydrogeological risk prevention, thus improving the effectiveness and efficiency of ES provision; and on the other hand, by improving the economic situation and survival chances of local farms.

Keywords: agricultural multifunctionality; multifunctional rural development strategies; farm diversification strategies; ecosystem services; payments for ecosystem services; flood prevention; farmers as custodian or guardian of a territory; Serchio basin; Tuscany

1. Introduction

This paper is based on the characteristics and results of a case study located in Tuscany and analyzes the provision of regulating Ecosystem Services (ES) aimed at increasing the territorial resilience to floods within the framework of a farm multifunctional strategy of diversification. The project described in the case-study report had a very pragmatic approach and was promoted by Tuscany Public Institutions with the main aim of improving the effectiveness and efficiency of resources used for actions of hydraulic and hydrological protection. These actions are necessary to prevent the negative effects of floods and landslides in an area where these phenomena have very severe and negative consequences; thus, in the following parts of the paper, for the sake of brevity, we will often refer to them as actions preventing the hydrogeological risk, although responsibility

for hydraulic and hydrological protection and for hydrogeological risk prevention rests on different Institutions. Unfortunately, ongoing processes such as unbalanced development and climate change demand an increase of resources committed to hydrogeological risk reduction and, due to the fact that fiscal pressure in Italy is already perceived as exceedingly high, especially in regards to real estate, this problem has to be faced in the context of a reduction of available resources. However, this project has also a positive impact on local rural development, insofar as it allows farmers to have an extra source of income, thus increasing the survival chances of farms in critical economic conditions and indirectly contributing to combating hydrogeological risk, since land abandonment is one of its main drivers.

Floods and landslides not only depend on human behavior since they were and are present also in the absence of anthropic drivers; nevertheless, the current model of development has contributed to increasing both the frequency of adverse phenomena and the magnitude of the damages they cause. However, human actions do not necessarily have a negative impact; they can also be directed towards the reduction of hydrogeological risk, both in its natural and human-made components. The case study should therefore be read within the theoretical framework of Ecosystem Services (ES) and Multifunctional Agriculture (MFA), i.e., as services that contribute to improve the flood resilience of a territory (ES) by means of actions performed by farmers (MFA). Due to its pragmatic approach, this case study has particular features differentiating it from most case studies presented in the literature that deal with the problem of ES provision by farmers through management of their own land. Contrariwise, our case study relates to the provision of ES by farmers via a separate economic activity, which directly aims at ES provision rather than being a consequence of the way farmers manage their own land.

The paper is structured as follows: Section 2 presents the theoretical framework of MFA and ES, providing tools for understanding the case study while stressing its specificity. Due to the pragmatic approach of the case-study project and the feature of "survival need" of the hydrogeological risk prevention [1], we have omitted the literature dealing with the economic evaluation of ES. In the same way, due to the fact that these services are provided through resources coming from taxes and other compulsory payments for real-estate owners, we have omitted the literature addressing beneficiaries' willingness to pay. Due to the focus of the paper, the examples given in this section are mostly related to hydrogeological risk issues.

Section 3 discusses the problem of hydrogeological risk in Italy and the contribution of farmer-provided ES. Although the prevention of hydrogeological risk through hydraulic protection mainly rests on major projects to be planned and implemented at the catchment level (dams, flooding areas, new channels, etc.), there is nonetheless a synergy between major projects and the interventions of local monitoring and light maintenance, which can significantly increase territorial flood resilience. This section includes an analysis of the different levels at which decisions influencing ES provision are taken. In particular, we highlight the importance of the following three levels: (a) farm level; (b) catchment level; and (c) regional, national and international levels.

Section 4 presents the socio-economic and biophysical characteristics of the case-study area since hydrogeological risk level and case-study results depend on the context where the project was developed. The analysis of the trends shown by the number of farms and by the utilized agricultural area (UAA) emphasize the importance of providing further income sources to farmers in order to avoid land abandonment and outmigration from mountainous rural areas.

Section 5 provides a description of the case-study characteristics and its main results. This section provides a brief history of the project, a summary of its strengths and critical points, and describes its results mainly in economic terms, i.e., cost reduction for the authority involved in hydrogeological risk prevention as well as an increase of farmers' income. Interviews with the farmers and authority employees made it possible to gather the data needed for a quantitative estimate of the above-described economic effects. Contrariwise, the analysis of the effectiveness of this new way of providing ES is only a qualitative one since a longer period of observation would be needed to properly estimate the variation in the level of effectiveness.

Section 6 provides concluding remarks on ES provision by farmers and the role of the institutions. The institutional context is not the only determinant of the success of the case-study project, since in other river basins with the same institutional context similar approaches have not been implemented. However, the authors are concerned that the ongoing process of restructuring of the authorities involved with hydrogeological risk prevention might hinder innovative and more efficient uses of local resources as the one described in the case study.

2. Agricultural Multifunctionality and Provision of Ecosystem Services

In their seminal work on Natural Capital and Sustainable Development, Costanza and Daily [2] stress the importance of including within Sustainable Development analysis not only human-made capital and labor, but also Natural Capital, whose stock should be kept constant in order to allow for durable development. Indeed, Renewable Natural Capital usually provides a flow of ES that is paramount in ensuring human well-being. Costanza et al. [3] define ES as "the ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being—the benefits people derive from functioning ecosystems." In most cases, ecosystems are not entirely natural but derive from the interaction between nature and human activities; this is, e.g., the case of agricultural landscape provision, which depends on agricultural and forestry land management (agro-ecosystems). ES includes provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease control; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits. Many benefits provided by Multifunctional Agriculture (MFA) can be considered as Ecosystem Services (ES). Both academic literature and policy documents recognize the multifunctional role of agriculture, i.e., "that beyond its primary function of supplying food and fibre, agricultural activity can also shape the landscape, provide environmental benefits such as land conservation, the sustainable management of renewable natural resources and the preservation of biodiversity, and contribute to the socio-economic viability of many rural areas" [4]. MFA and ES are both anthropogenic concepts that focus on human benefits. However, while the provision of goods and services in MFA is a direct result of agricultural activities, in ES it is a direct result of ecosystems that are influenced by farming activities. The ES approach was initially oriented toward natural ecosystems and blamed agricultural expansion for damaging ecosystem services, but has subsequently recognized agriculture both as consumer and provider of ES [5]. For example, the level of hydrogeological risk is influenced by rural land use management [6–10], since proper land management provides ES able to increase the resilience to adverse climate conditions. Thus, land abandonment in Less Favored Areas (LFA), mainly due to the economic unsustainability of farming and to broader regressive socio-economic drivers [11], is particularly relevant since, in these areas, "continued agricultural management (. . .) contributes to good soil and water management" [12]. According to the focus of the analysis (type of Ecosystem Service; demand or supply side), studies relate to different spatial units, such as farmland, landscape, basin or catchment areas, etc. For a review of the relations between sustainability, Ecosystem Services and human well-being at landscape level, see e.g., [1].

The ES literature considers ecosystem functions in the provision of services and prefers service-centered approaches, choosing spatial units according to the type of ES. Conversely, studies on MFA consider these functions as agricultural activity outputs and prefer farm-centered approaches [5]. From a farm point of view, multifunctionality refers to the provision of multiple joint products by an activity or a combination of activities [13,14]. For farms as business units, the distinction between commodity and non-commodity outputs is very important, since not all functions can be valued through the market. When outputs are of a marketable nature, they can be incorporated into a multifunctional development strategy. According to van Huylenbroeck et al. [13], from an analytical point of view, the term multifunctionality should not be mixed with other related but clearly different terms such as diversification or pluriactivity. Van der Ploeg and Roep [15] affirm that the structure of rural development at the farm enterprise level could encompass three different processes, namely

broadening, regrounding and deepening. Broadening relates to the introduction of new on-farm activities, thus resulting in an increase of farm income through diversification. Deepening relates to the transformation of agricultural activities in order to deliver products that have a higher added value per unit. Regrounding relates to off-farm income, i.e., pluriactivity, and to the use of internal resources with the aim of improving their efficiency. Although van Huylenbroeck et al. [13] stress the difference between multifunctionality and diversification, the term multifunctionality is often used to define multifunctional strategies of diversification [15,16]. According to Wilson [16] (p. 368), the main features characterizing strong multifunctionality are the following: (1) strong social, economic, cultural, moral and environmental capital and actors who show strong tendencies for local and regional embeddedness; (2) high environmental sustainability; and (3) a revaluation of existing farm household knowledge. The level of multifunctionality is important insofar as it influences the attitude and the willingness of farmers to engage in the direct or indirect provision of ES [17]. In the case that functions provided by farmers are of a non-marketable nature, they must find other means of evaluation and remuneration modes than the market [18], except in the case when a totally voluntary production is possible [17]. Muradian et al [19] affirm that, according to the mainstream 'Coasean' approach towards PES, the solution for market failure leading to the undersupply of ES is the creation of markets for environmental services trading. When the creation of markets is not possible, some other economic incentives are necessary in order to promote an adequate provision of ES. This is the case of aid given to LFA (now "areas with natural handicaps"), where the maintenance of farming activities is considered as a tool to reach environmental aims [12], and of agri-environmental schemes (AES), which compensate farmers for the production of non-commodity outputs such us biological diversity and soil conservation.

The search for the best tools to ensure a satisfactory provision level of ES shows an increasing importance in the agriculture and rural development policy agenda [20,21]. To face the problem of market failure in ensuring an adequate level of ES, Payments for Ecosystem Services (PES) are often provided. Most of the literature, following Wunder [22], refers to a PES as a market-based or market-like mechanism, where PES is designed to internalize benefits that are currently externalized, thus bringing marginal costs into closer alignment with marginal benefits and increasing economic surplus. Wunder [22] defines a PES as: (a) a voluntary transaction where; (b) a well-defined environmental service (or land use likely to secure that service); (c) is being "bought" by a (minimum one) service buyer; (d) from a (minimum one) service provider; and (e) if and only if the service provider secures service provision (conditionality). However, in real life it is very difficult to find situations where such an approach is workable, due to the characteristics of public goods of many ES. An alternative definition is that of Muradian et al., who define "PES as a transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources" [19] (p. 1205). Farley and Costanza [23] propose a new approach to PES, where they differentiate ecosystem goods as stock-flow resources and ES as fund-services in the sense used by Georgescu-Roegen [24] and define ecosystems as a particular configuration of stock-flow resources that provides a flux of services. Thus, PES schemes paying for land uses associated with generating the service are payments for ecosystem funds. Due to the complexity of ecosystems and of the flux of services they generate, Farley and Costanza [23] believe that payments for a bundle of loosely defined services are more likely to maximize social benefits than a (market-like) payment for a well-defined ecosystem service, as in Wunder's definition.

3. The Importance of Ecosystem Services (ES) Provided by Farmers in Reducing the Hydrogeological Risk in Italy

3.1. The Problem of Hydrogeological Risk in Italy

The concern for hydrogeological risk is high in the European Union Agenda as witnessed by the issue of a specific Floods Directive in 2007 (2007/60/EC) and by several recent documents (see, e.g., [25]). Hydrogeological risk in Italy and especially in Tuscany is particularly high. An inventory of

hydrological and geomorphologic catastrophes in Italy (1917–2000) has been done by Guzzetti and Tonelli [26], while an updated description of the current problems of hydrogeological risk in Italy has been recently provided by ISPRA [27]. According to the 2015 ISPRA report, the negative situation in Italy is due, on the one hand, to the geological, morphological and hydrological features of the territory; on the other hand, problems are the consequence of the steep increase of urbanized and industrialized areas, together with the development of linear transport infrastructures that, since the middle of the last century, have characterized Italy. The effects of these anthropogenic drivers on hydrogeological risk have been worsened by the lack of adequate territorial planning and by the strong diffusion of unauthorized constructions, i.e., urbanization abuses [27]. At the same time, the agricultural modernization process is determining negative effects on the hydrogeological equilibrium, mostly due to: (a) the concentration of agriculture on the most fertile lands; (b) the abandonment of marginal areas where mechanization is not possible and (c) the adoption of techniques, such as up and down slope ploughing rather than contour ploughing, which contribute to hydrogeological risk, e.g., through erosion and run-off [28]. Run-off patterns are also influenced by vegetation type and land management, which thereby ameliorate or exacerbate effects of extreme weather events on downstream settlements [8]. Consequently, agricultural activities, their abandonment included, can have both a positive and a negative influence on hydrogeological risk; a positive when they contribute to hydrogeological protection, and a negative due to land abandonment (lack of hydrogeological protection) or to the adoption of techniques that have a negative impact on the hydrogeological system. Upstream upland depopulation and land abandonment have increased the probability of floods and landslides, while the magnitude of their effects has been increased by the concentration of population and economic activities downstream and on valley bottoms [29]. According to ISPRA [27], Italy and Tuscany have 7.9% and 13.3%, respectively, of their surface in areas with high or very high landslide risk. These percentages increase to 15.8% and 24.0%, respectively, if also areas with intermediate flood risk are included. All municipalities in Tuscany have at least a part of their territory suffering from problems of hydrogeological risk (floods or landslides). Tuscany indicators of flood risk show that 25.9% of total population (Italy: 10.0%), 29.4% of economic activities' plants (Italy: 12.0%) and 19.6% of cultural heritage (Italy: 15.2%) reside in areas with intermediate flood risk. The only Italian region that shows higher values for the above indicators is Emilia-Romagna.

The catastrophic events that have occurred in the last years have caused the loss of human lives and severe economic damages (see, e.g., [30]), thus determining a high demand for regulating ES (i.e., flood prevention; increasing resiliency to floods); nevertheless, in Italy, the current financial situation of public institutions and the complexity of the governance of hydrogeological risk make their provision very difficult. The Italian body of laws related to water regulation and flood risk has been recently modified by the Water Framework Directive (WFD—2000/60/EC) and by the so-called Flood Directive (FD—2007/60/EC). An analysis of the slow and problematic implementation of the WFD can be found in Viaggi et al. [31]. A recent document [32] on the implementation of Flood and Water Framework Directives in the alpine context stresses the complexity of the inclusion of climate change impacts on the occurrence of floods, as asked by Article 4.2 of the FD. However, literature is starting to provide studies on models including this driver (see, e.g., [33]), also due to the important contribution of climatic change to the increasing frequency and magnitude of disruptive events related to hydrogeological risk [34].

In 2009, agricultural and forestry land accounted for 72.8% of the total surface in Europe and 68.1% in Italy [35]; consequently, farmers have a very important role in environmental management at the territorial level.

In this framework, an innovative approach is needed, such as the one developed for the Serchio River basin, which combines an effective and efficient provision of regulating ES at basin level with an improvement of farms' economic viability and farmers' social status, by promoting a multifunctional rural development strategy.

3.2. Farm Multifunctional Strategy, Ecosystem Services Provision and Importance of the General Context: A Three-Level Approach

In Section 2, we stressed that literature on MFA usually has a farm-centered approach, while ES analyses are usually based on larger spatial units, which depend on the type of ES. A third level of analysis is represented by the general (macro-level) context, which defines: (a) the boundaries of marketable agricultural activities, strongly influencing multifunctional strategies of diversification; (b) the policies aiming to promote an adequate provision of ES; and (c) the institutional framework for the authorities responsible for land management and prevention of hydrogeological risk. The importance of an analysis of the different levels of institutional context in the framework of designing or crafting change in Socio-Ecological Systems has been recently discussed in a special issue [36]. In this paper, our analysis has been organized into a three-level approach, i.e., farm level (micro), river basin level (meso) and regional, national and international levels (macro) (Figure 1).

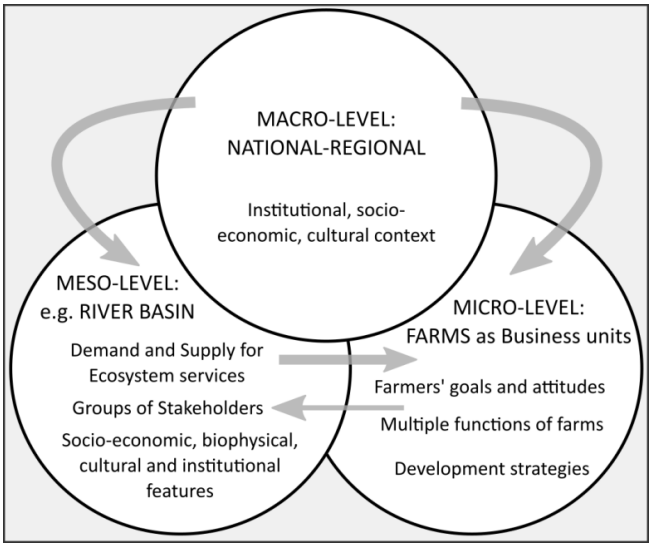


Figure 1. Micro, meso and macro levels of the analysis.

3.2.1. The Micro-Level (Farm) Analysis

The micro level, according to the MFA approach, deals with farms as units able to perform different functions, such as food and fiber production and ES provision. The production of these last types of output may span from a totally unsought process to a development strategy of diversification, passing through other situations such as technical necessity and choices due to personal attitudes towards good and responsible practices. Indeed, farmers' choices, as the ones of other entrepreneurs (see, e.g., [37]), are not only driven by economic or income reasons, but also by personal goals, cultural attitudes and a desire for social recognition [16,17]. Wilson [16], e.g., stresses the importance of social and cultural "internal" drivers of farm-level multifunctionality pathways such as social capital, farmer's embeddedness in the locality, as well as the role of farmer's attitudes and identity, etc. In the presented case study, the provision of ES comes from a direct and on-purpose activity mainly chosen for economic reasons (i.e., to increase farmer's income). However, farmers' personal beliefs and motivations likely influence the accuracy with which this activity is performed. Further ES could be indirectly provided by farmers through a more sustainable management of their own land, promoted by the awareness of the impact of their actions on community well-being.

According to Huang et al. [5] a multifunctional-agriculture approach has advantages for farm-level optimization analyses combining economic, social and environmental dimensions, while farm-level models are less common in ES research. Following Wilson's [16] definition of strong multifunctionality, relations between the micro and meso levels should be investigated (i.e., local embeddedness, etc.).

3.2.2. The Meso-Level (River Basin) Analysis

The ES approach usually needs to be carried out at the meso-level, since the analysis of ES asks for a larger territorial scale, such as the river basin (catchment) in the case of ES reducing hydrogeological risk. Several groups of stakeholders (i.e., public administrations, basin authorities, residents, farmers, other entrepreneurs, experts, etc.) who are interested in ES, either from the demand or from the supply side, are usually present in a basin. The provision and the importance of regulating ES are influenced both by biophysical (geological, morphological and hydrological) features of the basin and by socio-economic features linked to human interests. In fact, human interests can be seen either as drivers, when anthropic activities modify the natural level of risk, or as recipients of hydrogeological negative effects. In a situation where development processes tend to increase hydrogeological risk, farmers may provide ES such as monitoring and light maintenance of the hydraulic network able to decrease the risk, together with other valuable ES. Among the latter, there are the revitalization of rural areas and the conservation of the local knowledge on proper land management, at risk to be lost due to the processes of urbanization and cultural homologation. According to Gutman [38], a new rural-urban compact could be based on the sustainable provision of ES by rural areas, but it requires society's increased acknowledgement of the sustainable provision of ES by rural areas and the willingness to pay for them. Local institutions and other stakeholders could contribute to finding innovative and efficient solutions to the problems e.g., as in the case study described in Section 5, by valuing local resources in the framework of the institutional context defined at the macro-level.

3.2.3. The Macro-Level Analysis

The macro-level relates to the international, national and regional contexts that influence agricultural ES provision through, e.g., (a) the laws defining agricultural activities, which influence farmers' income opportunities; (b) the rules regarding public procurement, that public institutions—the Land Reclamation Consortia included—have to apply; (c) the international, national and regional laws related to hydrogeological risk prevention; and (d) the policies aiming to avoid the negative effects of farming activities or promoting positive effects representing public goods for which a market failure exists. Consequently, this level influences the other two levels discussed above.

In regards to the promotion of an adequate provision of ES, the role played by institutions could be related to:

(a) The creation of new markets;
(b) The implementation of PES schemes or other adequate policies, when market creation is not possible.

The creation of markets usually implies the introduction of property rights for goods and services in order to attribute them rivalry and excludability features.

In terms of the specific problem of hydrogeological risk prevention, it is important to stress that the possibility to consider nature management as an agricultural marketable activity is influenced by the legal framework. An analysis of Italian legal incentives and legal obstacles to diversification for farmers may be found in Albisinni [39]. According to Albisinni, the Legislative Decree (Lgs.D) 228/2001 on "Guidance and Modernisation of the Agricultural Sector" was issued in order to answer the challenges of European and Italian legislation. This decree, for the first time, included "activities aimed to protect values of land and of rural and forestry patrimony" within the so-called "agricultural connected activities" [39]. By law, an activity could be considered as connected (and, consequently, as an agricultural one) when it is carried out through the prevalent use of means or resources of the agricultural holding normally utilized in the agricultural activity performed [39].

The Italian Act 97 of 1994 on "New Regulations for Mountainous Areas," by simplifying procedures, aims to provide farm households with the chance of an additional source of income since, due to location in areas with natural constraints, their income is often low and farm survival is

put at risk. Indeed, Art. 17 of Act 97/1994 states that public bodies may award procurement contracts to farmers for services involving territorial management, waiving the very burdensome administrative procedures and rules for public procurement. A public procurement contract is a contract concluded by Public authorities to ensure the supply of works and delivery of services. These contracts, concluded in exchange for remuneration with one or more operators, are called public contracts and represent an important part of the EU's GDP [40]. The services awarded under Art. 17 can, e.g., be related to forest fire and hydrogeological risk prevention. Contracts can be awarded to farmers of family holdings located in mountain municipalities under the condition that farmers use only their own and their family's labor and farm-owned machinery. Art. 15 of Lgs.D 228/2001 has extended the possibility of procurement contracts between farmers and public administrations regarding territorial management also outside mountainous areas. This has made it possible for farmers to access the market of services for public institutions, which usually has very restrictive and specific rules. Last but not least, it is interesting to note that, according to Albisinni [39], the activity of land management is the only one with a potential conflict between European and Italian legislation. In fact, EU Regulation 1782/2003, and subsequently Regulation 73/2009, includes "maintaining land in good agricultural and environment conditions" in the definition of agricultural activity, while Article 2135 of the Italian Civil Code (as rewritten by Lgs.D 228/2001) considers these activities as agricultural only within the connected activities category, and not as agricultural activities per se. From this point of view, a further legislative action aiming to promote these activities in areas with natural handicaps, e.g., by relaxing the rules to be complied with for considering them as connected activities, would be desirable.

As regards policies to be implemented when market creation is not possible, based on Vedung [41], van Zanten et al. [42] classify them into three different groups: (a) regulatory instruments; (b) incentives; and (c) policies aiming to promote voluntarism.

Regulatory instruments apply penalties or sanctions in case of non-compliance to prescribed behavior. An example of an EU-level regulation is the Water Framework Directive where compliance with the set of norms of water quality is legally binding. Regulations usually consist of command and control policies, which are based on the definition of standards to be respected, e.g., in land transformation. They represent a "polluter pays" approach, since the cost of complying with a standard weighs on who is bound by it. According to Tempesta [43], command and control instruments only allow the negative impact of active and voluntary actions to be reduced, but they are ineffective in opposing passive transformations caused by the abandonment of an activity. In the case of abandonment of forestlands, e.g., the lack of proper management has negative effects, whereas, if properly managed, forestlands would positively contribute to hydrogeological risk prevention.

Incentives (or disincentives) encompass taxes, payments and subsidies as well as trading schemes and ownership rights. They are setting either positive (economic aid) or negative (taxes) incentives to market participants to follow an intended behavior. Agri-environmental payments represent important examples. As regards PES, it is interesting to note that they imply the shift from the "polluter pays principle" to the "beneficiary pays principle," as stressed by Smith et al. [44]. In this case, the cost of producing ES has to be borne by the end beneficiaries, either through voluntary or compulsory instruments. According to Huang et al. [5], the identification of beneficiaries is crucial for ES valuation, because ecological structures and processes are not translated into ecosystem services until directly or indirectly consumed by humans.

Policies promoting voluntarism include information instruments, which are classified into (a) voluntary agreements, born from intrinsic motivation; and (b) suasory instruments. Suasory instruments aim at moral suasion of objective information and subjective value patterns of single economic decisions by individual decision makers by, for example, informing about social costs of behavior, pleas for ethical behavior, non-monetary social sanctions, etc. [42]. Thus policies related to the promotion of a cultural change, such as those aiming to increase the awareness among residents of the important role played by farmers or promoting an open attitude towards collaboration among different stakeholders, can be included in this group. Bouma et al. [45] highlight that "creating more awareness, by sharing

experiences with various citizen groups, is also an effective mechanism to mobilize the political arena (. . .). Innovation in sustainable management of soils requires co-production of knowledge and technologies involving research scientists, policy-makers and land managers." As we will see in Section 5, the same remarks could be applied to the problem of hydrogeological risk prevention.

While this last group of policies requires more time before giving results, in many authors' opinions, these policies are able to bring about more durable effects, where the provision of ES or the adoption of environmentally sound behaviors tend to survive even after the disappearance of constraints and economic incentives [17]. For an analysis of the tools that could be implemented in order to correct market failures in the specific case of services provided by multifunctional farms and rural territories, see Aimone et al. [46].

In the case of hydrogeological risk, the adoption of an environmentally friendly behavior by farmers and the populace is not sufficient to cope with the risk, but there is a need to realize specific projects or interventions (dams, flooding areas, etc.). These interventions fall under the responsibility of authorities that work at basin level. Thus, it is important to describe the legislation dealing with hydrogeological risk prevention, to which the following sub-subsection is dedicated.

3.2.4. The Legislation about Hydrogeological Risk Prevention and Land Reclamation Consortia between Macro- and Meso-Levels

The legislation of water governance and land reclamation has a long history, beginning with old sectoral discipline such as the Royal Decree No. 523/1905 (Consolidated Law on water projects) and the Royal Decree No. 1775/1933, the so-called Serpieri's Law, on Integral Land Reclamation [47]. In terms of hydrogeological risk prevention, although Italy has always had a long and dramatic history of extreme events such as landslides, flooding, land degradation and drought [48], there has nevertheless been a heavy delay in the issuing of laws making compulsory the inclusion of natural risks, such as landslides and floods, in territorial and urban planning; a delay that lasted until Law 183/1989. The only exception of this is the Royal Decree No. 3267/1923, which focused on hydrological constraints, forestry management, and maintenance and improvement of forest waterways and terrain. Law 183/1989 regulating soil and water protection introduced a fundamental innovation, namely the establishment of the river basin as basic territorial reference [27], and yet the institutional framework dealing with hydraulic and territorial management has remained quite complex. A detailed analysis of the authorities involved in hydraulic and water management from the national to local levels and of their role is provided, for the area where the case study is located, by the Waterincore project [47]. Among authorities dealing with hydraulic risk prevention at the local level, both Mountain Communities, which have been recently converted into Municipality Unions by Tuscany Law 37/2008, and Land Reclamation Consortia (Consorzi di Bonifica) are very important. Land Reclamation Consortia have been operating since the beginning of the last century and they are formed by real estate owners and local authorities' delegates of the relevant territory (e.g., some of the mayors of the municipalities included in the area under the responsibility of the Land Reclamation Consortium). They coordinate public interventions and private activities concerning hydraulic network maintenance and irrigation. The cost of ordinary maintenance, managing and safeguarding of reclamation works is covered by the financial support of the real estate owners. Only in the case of new hydraulic projects and extraordinary or exceptional maintenance of the old ones, does the Tuscany Region cover 70% of the cost while the remaining share is paid by the private members on the basis of the benefit that projects and land reclamation activities provide to each of them. Land Reclamation Consortia were initially founded by land owners, mainly farmers, willing to protect lowlands from floods and to face problems related to malaria, while urban settlements, which were mostly located at a higher altitude, were less concerned with these problems. Recently, the importance of defending urban and industrial settlements from hydrogeological risk has increased, while the private component in managing Land Reclamation Consortia has lost momentum in favor of the public component. Land Reclamation and Irrigation Consortia are very important bodies in Italy,

because they coordinate public actions and private activities, aimed at safeguarding the territory, its environmental protection, the hydraulic shelter, the development of agriculture, and the management of water. Further information on Consortia, the evolution of the relative body of law at national and regional levels, and the relationship between participatory irrigation management and the consortia can be found in Billi et al. [49].

Land Reclamation Consortia were ruled by the Tuscany Regional Law 34/1994 on "Rules on Land Reclamation", under which the "Comprensorio di Bonifica n. 4—Media Valle" was created in 1996. The Regional Law 79/2012 on "New regulations on Land Reclamation Consortia" has recently reorganized these public bodies and the Comprensorio di Bonifica n. 4 has been merged together with other three in the Consorzio di Bonifica 1—Toscana Nord (Land Reclamation Consortium 1—Northern Tuscany). The reorganization in Consortia managing larger territories was made in order to reach economies of scale and rationalize administration. However, the old organization based on Mountain Communities and small Land Reclamation Consortia was, in our opinion, more suitable for involving the real estate owners and for implementing participative and collaborative approaches to the management of the hydraulic network. Thus it is important that, even if the reorganization is functional from the point of view of cost reduction and of gaining a wider picture of the hydrogeological problems of territories, the relationship with people who live and/or work in the area is not lost.

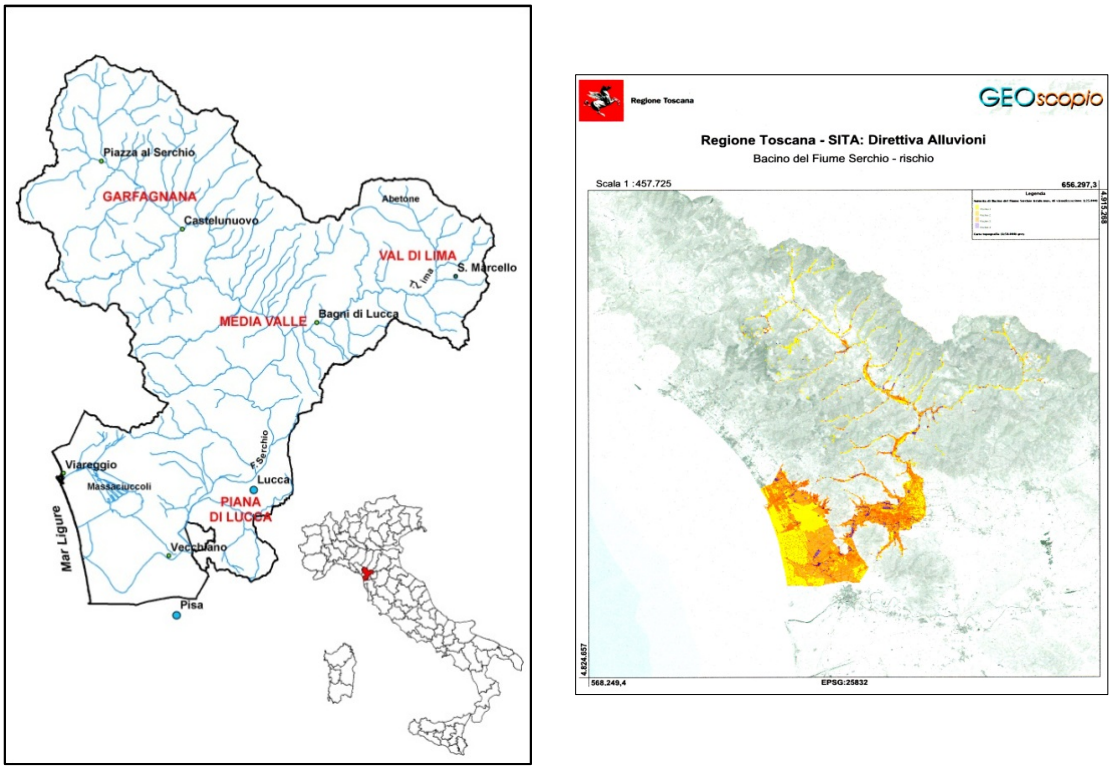
4. The Case-Study Area: Main Features of the Serchio River Basin, Tuscany (Italy)

As we have pointed out in Section 3, Tuscany Region has the second highest level of hydrogeological risk in Italy. Within Tuscany, Serchio basin presents particular features of hydrogeological instability, seismic risk and water pollution, and for these reasons it has been constituted as a "pilot basin" (see Art. 30) for Tuscany Region in the implementation of the Law 183/89 and also for WFD [48]. Recently, it has been characterized by important negative events such as the flood of Serchio River in December 2009 and that of "Alta Lunigiana" in October 2011. These events had a very high cost both on human lives and economic resources. While an estimation of damages of the most recent events is not available, the 1996 flood in Alta Versilia and Garfagnana caused 15 deaths and 230 million Euro were needed for reconstruction and in order to make the area safe [50]. Indeed, a proper policy of prevention would very likely cost less than repairing damages after floods.

The natural hydrogeological features of the territory make this area very prone to floods and landslides. Recently, this situation has worsened due to the effects of climate change and of an unbalanced process of development. To better understand the basin situation, a short description of its natural and socio-economic features is given below.

The area of the Serchio basin (Figure 2a) is located in the North-West of Tuscany. It includes, partially or totally, 37 municipalities, 28 located in Lucca province, while the remaining are located in the provinces of Pistoia (six municipalities) and Pisa (three municipalities). The basin area (ca. 1565 km^2) presents particular features of hydrogeological instability. The upstream area, which includes Garfagnana, Media Valle and Val di Lima, accounts for more than 66% of the basin surface. However, the population is mainly concentrated downstream, i.e., Piana di Lucca, Versilia and Pisa coastal area, where ca. 75% of the basin's total population lives (Source: Basin Authority website).

The map of risk estimation (Figure 2b) for the Serchio basin has been drawn for the implementation of the Flood Directive. Although the prevention of the hydrogeological risk made upstream is paramount in reducing the risk, the risk estimation map shows that floods mainly impact downstream lowland areas.



(**a**) (**b**)

Figure 2. (**a**) Position of Serchio basin inside Italy; (**b**) Risk estimation in Serchio basin (Flood Directive). Source: (**a**) Serchio Basin Authority [51]; (**b**) Tuscany Region—Geoscopio [52].

According to the Tuscany Regional Plan of Territorial Guidance with value as Landscape Plan (Piano di Indirizzo Territoriale con valenza di Piano Paesaggistico), issued in 2015 [53], in Garfagnana, Media Valle and the part of Val di Lima located in Lucca province, which are representing most of the upstream area of the Serchio River basin, the post-WWII crisis of subsistence agriculture and chestnut tree cultivation brought about an almost generalized "exodus" from villages located in mountainous and hilly areas. As in other areas of Tuscany, there was a heavy depopulation of the mountains and increased urbanization of the richest areas, which mainly occurred between 1951 and 1971. During the 1980s, this process slowed down and in some areas there even was an inversion of this tendency. An analysis of demographic trends in the municipalities of Tuscany between 1861 and 1998 is given in Andreoli et al. [54]. As regards the specific situation of Garfagnana, Media Valle and Val di Lima, the population decreased from 74,011 inhabitants in 1951 to 59,302 in 1971, although in more recent times, this process continued at a slower pace. In 2010, the population was 51,972 inhabitants. A separate analysis of the municipalities in the upper and lower parts of the Serchio basin has been performed on the base of their whole territory. Thus, since some of them are only partly included, data refer to a total surface of 2337 km^2 even if the river basin accounts only for 1565 km^2. From this analysis, it becomes apparent how these sub-areas differ from each other. The upper part, i.e., Garfagnana, Media Valle and Val di Lima, shows a continuous decrease in population between 1951 and 2011; moreover, it has a population density of ca. 72 inhabitants/km^2, which is much lower than the one of the downstream areas. The lower part, i.e., Piana di Lucca, Versilia and Piana di Pisa, shows an increase in population between 1951 and 2011, and has a density of population of ca. 397 inhabitants/km^2.

The process of migration has happened both among municipalities, with people moving to the richest municipalities of the area in order to have better access to jobs and services, and inside municipalities, with people leaving scattered houses in difficult locations and moving to the main centers, usually located in the bottom of the valley, as confirmed in the case of Garfagnana [55].

The abandonment of scattered houses usually brought about the abandonment of neighboring land, which was previously cultivated. Thus, as a consequence of depopulation, there was also a diffused land abandonment and, due to the absence of crops, also the light hydraulic maintenance and land erosion prevention activities ceased [53] (p. 14).

The Plan of Territorial Guidance [53] (p. 34) highlights also the sharp increase of urban "nodes" with the growth of the urbanized surface between 1954 and 2012. The localization of both population and economic activities are deeply influenced by the features of the territory, since they tend to concentrate in the valley bottom, close to main transport infrastructures, where they have better accessibility. The river basin morphology, combined with a high amount of rainfall, determines short "corrivation times" or times of concentration, usually defined as the time required for a particle of water to travel from the most hydrologically remote point in the watershed to the point of collection, causing the bottom of the valleys to be included among the areas with the highest hydrogeological risk in Tuscany. Corrivation time can be considered as an index summarizing the susceptibility of a basin to a flash flood [56].

Economic development and urbanization worsened the situation by breaking the old equilibria among territory and mankind, which was characterized by the use for human activities mainly of the part of the territory situated between 500 and 800 m.a.s.l. According to Bastiani et al. [57], since the 1950s, the residential areas have expanded to the bottom of the valley, leading to the saturation of significant parts of the flat terraces, in some cases including even floodplains. The tendency of the settlements to concentrate at the bottom of the valley instead of exploiting other possibilities offered by the topography of the area has created congestion and infrastructure problems. Industry, especially paper mills, is also localized along the river and has a tendency to extend to the riverbeds. Residential zones and industrial areas occupy approximately 13% and 7%, respectively, of the basin. Currently, they almost entirely occupy the bottom of the valleys, causing an over-exploitation of natural resources and pollution problems, besides the loss of "common responsibility" as regards environment [58].

If urbanization of the bottom of the valley is one of the anthropic drivers increasing the hydrogeological risk, the abandonment of the agricultural use of the highest parts of the territory has negative effects, too, such as the loss of the traditional knowledge about best practices for territorial uses, of cultural identity, and of local control of the territory.

The abandonment of farming activities very often takes the form of an increase of woodlands that are not adequately managed, due to the economic unsustainability of wood produce. Although reforestation is very often seen as a positive phenomenon since it is seen as a form of renaturalization, some authors (see, e.g., [59]) criticize the policies promoting the indiscriminate increase of woodland in Tuscany. In the case-study area, e.g., the spread of woodlands that no longer have an economic purpose constitutes a threat, since an excessive weight of trees increases landslide risk. The Italian National Research Council project IPRA (Increase of the Productivity of Agricultural Resources) in the '80s pointed out the risk of an excessive expansion of woodlands in areas that were formerly destined for grassland, since grassland provides a better service of hydrogeological risk prevention than woodland in areas characterized by steep slopes and landslide risk [60] (p. 16). Last, but not least, the deterioration of the environmental quality level of the area as regards to hydrogeological risk may start a cumulative circle of causation due to the increase of abandonment of the area in consequence of its hydrogeological fragility [61] (p. 284).

Since agricultural land abandonment is one of the drivers of hydrogeological risk, we have summarized in Table 1 the main changes to agriculture in Lucca Province (where most of the river basin area is located) by territorial area. The average values for Tuscany are given as terms of comparison.

Table 1. Lucca Province Agriculture—main 2010–1982 changes by territorial area.

Territorial Ambit	Farms at 2010 (N.)	Δ N. of Farms 2010/1982 (%)	Δ Total Agric. Area 2010/1982 (%)	Δ Utilized Agric. Area 2010/1982 (%)	UAA/TAA at 2010 (%)
Garfagnana	1090	−72.9	−61.2	−54.3	45.4
Media Valle	1023	−74.4	−61.9	−54.2	33.4
Piana di Lucca	2503	−70.7	−38.3	−35.7	67.0
Versilia	1927	−68.4	−50.2	−48.4	64.1
Lucca Province	6543	−71.1	−55.0	−47.2	51.6
Tuscany Region	72686	−52.1	−27.5	−23.8	58.2

Legend: TAA: total agricultural area; UAA: utilized agricultural area; Source: ISTAT, Agricultural Census Data [62].

According to Table 1, Lucca province has experienced a sharp drop in the number of farms (−71.5%, in comparison with −52.1% of Tuscany on average), probably due also to the small farm size that is a characteristic of agriculture in this province. The drop is higher in the upper part of the province, where this phenomenon reaches −72.9% in Garfagnana and −74.4% in Media Valle. When analyzing agricultural evolution and its contribution to ES, such as water regulation or landscape conservation, land abandonment is a more powerful and negative driver than the drop in the number of farms, which could be due to a physiological process of agricultural sector restructuration. In other words, what is important is to keep farmland inside a sustainable productive system and not to prevent land acquisition by stronger farms [63]. In this framework, the sharp decrease of Total Agricultural Area (TAA) by more than 60% both in Media Valle and in Garfagnana, and that of Utilized Agricultural Area (UAA) by about 54% both in Media Valle and in Garfagnana, is much more negative, because it means that this land has been totally abandoned or used for other purposes, i.e. industrial or residential uses. As regards the agricultural use of land, according to the ISTAT 2010 Agricultural Census [62], woodlands account for more than 50% and 60% of the TAA in Garfagnana and Media Valle, respectively. As regards UAA, permanent grassland accounts for about 25% and 21% while arable land accounts for about 13% and 5% of the total, in Garfagnana and Media Valle, respectively. These data witness a very difficult situation for the agriculture of these areas, where almost only extensive livestock rearing is an economically viable activity. If the destiny of a single farm is not important, provided that its land remains in productive use, a problem arises when the economic unsustainability of agricultural uses is widely spread in an area due to its pedoclimatic and socio-economic features. Indeed, as Andreoli et al. [61] commented about the situation of virtual abandonment of some Garfagnana farms in the '80s, the wonder was not that these farms were closing down, but that other farms almost with the same features were willing to carry on.

For the above reasons, the Territorial Guidance Plan of Tuscany [53] considers abandonment as one of the main critical points of this area. From this point of view, in order to allow farmers to keep on farming and living in the area, it is paramount to provide them with new sources of income, e.g., promoting farm diversification by provision of land management and environmental services, as currently made possible by Lgs.D 228/2001.

5. The Project "Farmers as Custodian of a Territory": Description, Results and Discussion

The information and data included in this section mainly derive from the experience gathered from one of the authors during the evaluation of the project "Farmers as custodians . . . " made in the framework of a research on "The role of farms in the protection of mountain territories from hydraulic and hydrogeological risk. An analysis of the constraints and opportunities related to monitoring and light maintenance contracts between Land Reclamation Consortia and farmers", which provides a detailed SWOT analysis on the issue of the farmer's role, giving some guidelines for future strategies. The analysis has been based on project documents and in-depth interviews with eight people chosen among public officers and technicians of several public institutions (e.g., Land Reclamation Consortium, provinces, municipalities, and mountain communities), two people involved in the development of the software IDRAMAP [64] and four farmers among those who have been involved in the project

as custodians [58]. The analysis of the project impacts has been carried out also on other farms, e.g., the one for which more information is given in Section 5.2. The aforementioned research project was financed by ARSIA, the former Tuscany Regional Agency for the Development and Innovation of the Agricultural and Forestry Sector.

The case study was chosen because in the literature there are mainly examples of ES supplied by farmers through the management of their own land while, in this case, there is an ES direct supply by farmers through activities carried out outside their own farms. In the authors' opinion, the case study shows that with an innovative approach it is possible to obtain good results in a relatively short time and with very limited resources. In this specific case, the approach adopted seems to be beneficial for almost all the groups of stakeholders.

5.1. The Project "Farmers as Custodians of a Territory" and the Problems It Addressed

In this sub-section, we describe the Project "Farmers as custodians of a territory" that for its innovative approach and its effectiveness and efficiency is a perfect case study of what it is possible to do with a more "creative" approach towards ES [28,57,58,64–72]. The project stems from the peculiar context of the Serchio Valley and aims to address two separate problems:

(a) The scarce endowment of human and financial resources, which created a situation where the Land Reclamation Consortium N. 4—Valle del Serchio (often "the authority," in the following part) had increasing difficulties in guaranteeing both direct activities aimed at territorial protection from hydraulic hazards, and a satisfactory level of monitoring and maintenance of the territory of ca. 115,000 ha of mountainous areas, ca. 1500 km of streams and torrents, whose riverbeds need cleaning, maintenance and bank restoration, and ca. 2500 hydraulic structures, such as dikes, needing regular maintenance [67].

(b) The process of abandonment of agricultural activities, mainly due to socio-economic drivers, which is exacerbating an already critical situation.

The lack of resources is due in part by the current situation of Italian public finances, which has caused Tuscany Region to reduce its contribution to the consortium and also in part to the taxation on real estate, which owners perceive as already too high. Consequently, the Land Reclamation Consortium cannot gather from private members the resources lost from public sources, since its private members are very sensitive to any increase of burden on real estate taxation. In this framework, the low willingness to pay for these ES is not caused by an underestimation of their importance, but by the fact that beneficiaries already consider their tax burden as unsustainable, and often raise doubts about the effectiveness of expenditure.

On the other hand, the already fragile territory managed by the Consortium was affected by a strong decrease in agricultural and managed forestland, due to the difficult farming conditions in upstream mountains, and to the change of destination of the more fertile and accessible lands from agriculture to industrial or residential uses. Over time, the processes of agricultural and rural exodus have lowered the level of territorial monitoring and maintenance provided by farmers and private citizens and they have eroded the heritage of knowledge regarding the best practices to prevent hydrogeological risk and the awareness of the importance of territorial custodianship.

Thanks to an idea of a former manager of the MC of Media Valle del Serchio, the problems described above were addressed in an innovative way by awarding to farmers contracts for services of monitoring and light maintenance of the hydraulic network. This scheme was potentially and, in the authors' opinion, is more efficient and effective than contracting specialized firms, which sometimes are not locally based, for the following reasons:

- Farmers already know the territory in the area around their farms, due to their leisure activities (hunting, fishing, wild berry picking and gathering of mushrooms);
- The activity of monitoring, if integrated into these leisure activities, has a very low cost for the farmers;

- Farmers live in the area and so the time needed for urgent interventions is very short and the cost for transfer is comparatively low. This is particularly important in the case of "alerts" since farmers can check the state of the hydrological network at a short notice;
- Farmers already have some expertise in forestry management and light maintenance because they need it for their farming activities;
- Farmers have a lower hourly cost since they tend to use for these monitoring activities time that would not otherwise be spent on farming (end of the day, winter period, etc.), thus having a low opportunity cost;
- Because farmers understand the damage that can be done by inadequate monitoring and maintenance of nearby rivers and torrents, they are aware of what is at stake and are consequently more motivated;
- Farmers know the owners of the land that borders the rivers and streams under their care and can thus facilitate relationships between other landowners/land managers and the Land Reclamation Consortium in the case that maintenance involves some activity on another's private land.

The project started in 2007, as a pilot initiative, in consequence of an agreement drawn by the MC of Media Valle with the contribution of one of the farmers' trade unions. Firstly, the MC individuated the best practices for the management of the territory; then, it bid for farmers interested in providing services to the MC; and finally, selected them according to their professional skills, location of the farm, knowledge of the nearby territory, as well as adequate availability of labor and machinery. Among the 63 farmers who had shown interest in this project, 60 were considered as possessing adequate characteristics. After the selection, transects were jointly made by MC experts and farmers, in order to evaluate: (a) the initial maintenance state of the hydraulic structures; (b) their importance in improving the territorial resilience to floods; and (c) to individuate which were the areas more in need of intervention. On this basis, under the constraint of a limited budget, 20 agreements were made with farmers, to which two different activities were awarded:

- *The monitoring of the territory as regards the state of maintenance of the hydraulic structures*. The activity of light maintenance (see next item) was often provided by subjects who were external to the Consortium and codified among the works that could be awarded by public bodies. On the contrary, the service of monitoring was more "borderline" with respect to the Lgs.D 228/2001 and there was special attention paid to organizing it in order to avoid legal problems. Farmers were required to present regular reports, which included digital photos and GPS coordinates of the hydraulic structures they were monitoring, so as to adequately map those structures and their level of criticality as well as prove their monitoring activity. Significantly, the use of a digital camera and of information technology tools were among the most critical points of the project since farmers, especially if elderly, had problems using them. Monitoring activities were prevalent during the period 2007–2008 since it was necessary to develop a database of the main environmental needs and characteristics of the area, e.g., mapping rivers, torrents, channels, hydraulic structures, etc., and checking their current state.
- *The execution of simple maintenance works*, i.e., the removal of fallen trees from riverbeds and the management of riparian vegetation in order to ensure a regular flow of water [58,67]. Ex ante joint transects made by farmers and authority technicians to agree on the works needed and ex post control of their execution were improving co-learning processes. These processes allowed farmers to increase their knowledge and skills and, at the same time, allowed technicians to take advantage of the local knowledge of critical areas and of traditional techniques.

During the second year, only some of the previous agreements were renewed. Only 13 farmers were included in the continuing project; those with the best results for the initial period were chosen to stay on. After the first period, the budget allocated to monitoring activities was reduced since an adequate knowledge of the territory had already been attained [58,67]. The information about the

state of the hydraulic network and structures provided by farmers, together with information coming from other sources, is organized in a WEBGIS with DSS functions called IDRAMAP [64], which can be also used by private citizens in order to notify the authority that there are urgencies or maintenance activities to be done in a specific location.

In the operating year 2010/2011, agreements were made with 29 custodians, among which 25 were farmers and four were cooperatives. They were awarded the monitoring and light maintenance of 40% of the territory, where ca. 33% of the hydraulic network is located, with a total cost of 44,000 € for the authority. Usually, there were no problems in finding farmers ready to enter these agreements. However, since many farmers were interested but only some of them could be financed with the available budget, the authority had the problem of proper selection of custodian farmers.

5.2. An Example of the Results: The Torrent Sestaione and Its "Custodian" Farmer

The farm of Sichi Elda was taken as an example of a farmer custodian. This farm is located in the basin of Sestaione torrent (Val di Lima) in a place with severe accessibility problems. The area where the farm is located presents criticalities and frequent negative events arising from an unsatisfactory management of the territory in terms of hydraulic protection. The farm survey made it possible to gather the data needed for evaluating the economic impacts of the activity of custodianship, both on farm income and on the cost borne by the Land Reclamation Consortium.

The farm is located in the municipalities of Abetone and Cutigliano, i.e., in the part of Val di Lima belonging to the Pistoia province; although the previous analysis of the case-study area focused on the part of Val di Lima included in Lucca province, the part included in Pistoia province has very similar features. This area ranges from an altitude of about 900 m.a.s.l. to about 1940 m.a.s.l. and, in recent times, it has suffered important floods, in 2008, in 2009 and at the beginning of 2010.

This farm manages about 20 ha of land, 18 of which are owned by the farmer. It is a family-holding having as main activities the production of firewood coming from its own woodland, berry picking and the production of decorative greenery, mostly for Christmas decorations.

Before awarding the activity of custodianship, the authority checked the presence of adequate requisites, namely a good knowledge of the area by the farmer, the availability of adequate machinery and expertise for providing the services that were the object of the agreement. The area of interest consisted of a territory of 1600 ha, which includes a 22 km stretch of the Sestaione torrent and 14 hydraulic structures. Table 2 provides a comparison of the cost borne by the public authority for awarding the monitoring and maintenance activities to this custodian farmer (see column "farmer") and an estimate, based on standard fees, of the cost that should have been borne if the authority had executed these tasks on its own or awarded them to a specialized firm (see column "Others"). While the costs related to "Farmer" are those effectively borne by the authority, the costs included in the columns "Others" are an estimate. The hypotheses that have been made are the following:

(a) Monitoring: 2 visits/month which ask for 4 h/visit (transfer + individuation of the specific location + monitoring + writing the report) with a cost of labor of 31.13 €/h for the monitoring activity plus a cost for the transfer from the city where the closest office of the authority is located (60 km return trip) at an average cost of 0.25 €/km (total cost for labor + transfer = 3,348.48 €/year);

(b) Maintenance: In the case of the farmer, the labor was remunerated at 18.75 €/h all included. In the case of use of employees of the authority or the award to an external firm, the hourly cost would have been 51.04 €/h. The tariffs and times of execution have been taken from the data used by Tuscany Region to estimate the cost of the execution of forestry works [58].

Table 2 shows that the direct award to the custodian farmer saved more than 60% for the public authority. Furthermore, it has allowed a shorter delay in interventions in the case of urgencies. Cost saving is very important since it allows the authority either to carry on providing a satisfactory level of ES in the context of a lowering budget or to ensure better ES without burdening real estate owners with the request of a higher economic contribution. In regards to effectiveness, floods that occurred during the period under analysis resulted in smaller negative effects on the territory, thus

highlighting the role of a good and timely maintenance of streams, torrents and rivers in reducing damages caused by heavy rainfall. However, it is not possible to quantify the increase of effectiveness compared to the previous situation because the period of analysis is not long enough.

Table 2. Cost and saving of awarding monitoring and maintenance activities to the farmer rather than using Authority workers or external specialized firms (Others).

	Cost of Monitoring Activities in Euro, if Provided by		Labor Required for Maintenance	Cost of Maintenance Activities in Euro, if Provided by		% Cost Saved
Year	**Farmer**	**Others**	**Labor (h)**	**Farmer**	**Others**	
2007	2,250.00	2,988.00	337	6,312.50	17,183.47	57.6%
2008	2,250.00	2,988.00	226	4,240.00	11,541.85	55.3%
2009	1,200.00	2,988.00	153	2,860.00	7,785.30	62.3%
2010	500.00	2,988.00	302	5,660.00	15,407.27	66.5%
2011	500.00	2,988.00	293	5,501.07	14,974.65	66.6%
Total	6,700.00	14,940.00	1311	24,573.57	66,892.53	61.8%

Source [56].

Thus, the direct award to the farmer allowed:

- A consistent decrease of costs for the authority responsible for the hydraulic maintenance and protection of territory from hydrogeological hazards;
- An increase of the quality of the ES provided to the community, due to the more timely detection of problems and consequent quick interventions, together with a higher accuracy in the execution, due to the fact that farmers are highly motivated;
- A consistent increase in the farm's income, since the 6,500 € received by the farmer against the provision of the ES represent ca. 15% of the total farm revenue without any increase in fixed costs (labor, machinery), which are the most important costs needed when providing the service. Consequently, this extra income may cause a shift towards farm viability in the balance between economically sustainable and unsustainable farm results.

Other and more general positive effects of the project will be discussed in the next subsection.

5.3. Results Discussion

5.3.1. The Project "Farmers as Custodians of a Territory" and Its Achievements

In the previous subsection we have given some results of the project from a strictly economic point of view. Someone could argue that there is no need for a theoretical approach to externalities, multifunctionality or ecosystem services. Indeed, the farm carries on an on-purpose economic activity that provides an environmental service, which could be provided also by specialized firms. The Land Reclamation Consortium simply follows economically rational behavior by choosing, among possible providers, the ones who ensure lower cost or a better ratio between quality and cost of the service. Indeed, according to the strict definition of agricultural multifunctionality by Van Huylenbroeck et al. [13], in this case the maintenance of the territory is not a "joint product" of the farming activity, but an economic activity in itself, which diversifies farm income, i.e., farm multifunctionality linked to agro-services, which are remunerated by market or incentives ("multifunzionalità agroterziaria") [46].

However, in this project, there is more than first meets the eye. First of all, it is important to stress that farmers belonging to the project "custodians" are paid for activities to be performed in an area close to their farm, not on their own land. This scheme is thus placed outside the sphere of multifunctionality and PES mainstream approaches on land management, where farms usually get economic incentives for doing or not doing something on their own land. Conversely, in the case of the project "Farmers as custodian," the situation is different. As regards the economic aspects, it is obvious that farmers

want to be paid for the labor and machinery needed for maintenance activities. Nevertheless, in this specific case, there is no conflict between "productivity" and "custodianship" [17], since the activity as custodian does not usually interfere with the traditional farming activities. This "new" activity may also make it profitable to buy new or better machinery. The economic profitability of these agreements is confirmed by the fact that there are cooperatives and farmers who, after entering this project, are planning to specialize in the provision of similar services. This could be seen as a threat for small farmers, since large cooperatives have more chances than small farmers to be awarded maintenance contracts. We remind the reader that in this case the activities aimed to protect values of land, etc., are considered as agricultural activities by Italian law only when they are "connected" to principal agricultural activities (see par. 3.2.3). As regards the legal aspects, even if farmers would be willing to be involved in maintenance on a voluntary and autonomous base, there would be a problem of property rights, since the activity is carried out outside the land they legally manage. Indeed, were a farmer mowing or pruning a private garden or a public park without any authorization because he/she does not like the way it is kept, he/she could be sued for trespassing since he/she has no right to do it. In the same way, except maybe in case of emergencies, the farmer could not maintain riverbeds (which are public property) or riverbanks belonging to other landowners without having proper authorization, also in the case that the work is done on a voluntary base.

The second important aspect to stress is related to concepts of participation, joint learning and co-production implemented in this project, where, e.g., a better knowledge of the territory is deriving both from the "grassroots" knowledge of local farmers and the scientific and technical expertise of the authority employees/experts. Furthermore, the agreement was designed with the participation of a farmers' trade union (Coldiretti) and the relationships between farmers and authority officials regarding the services have created a collaborative environment. The project brought about the awareness that hydrogeological hazard prevention is something that needs a collective approach since the results are contingent on all parties on the territory taking responsibility. The effort expended by farmers for proper management of their own land is increased by the awareness that this activity is not isolated, and consequently having limited effects, but it is a part of a collective effort able to truly improve territorial protection on a wider scale. Furthermore, the awareness of the importance of monitoring the territory has spread among other farmers who in some way now participate in a network dealing with this problem. It is important to note that, while the direct award of monitoring and maintenance activities could be classified as an on-purpose activity aimed at income diversification, it nevertheless also has "joint products" related to the permanence of farming activities that otherwise would be at risk of abandonment. Consequently, together with a revitalization of the local rural economy, it could have other positive joint effects, e.g., the control and maintenance by the farmers of their own land, the conservation of traditional rural heritage, etc.

Although private reasons such as the extra income and the access to a better relationship with MC employees (that could be useful in many cases) were among the motivations given by farmers as reasons to join the "farmers as custodians" project, nevertheless there were also other important reasons related to their personal passions, skills and ideas and, above all, to the project contribution in renovating their identity as farmers, which in many cases is closely linked to the social and institutional recognition of their role as "custodians" of the territory. From this perspective, many farmers have emphasized that their participation in the project makes them feel directly involved in the management of the territory, which gives them a social role, since the services provided increase the awareness of local communities regarding the importance of the farmers' stewardship in mountain areas [65].

Thus, the approach of many farmers as custodians could be better understood in the framework of Wilson's strong multifunctionality definition [16], that stresses the importance of local embeddedness and that of "associational interfaces," which are highly significant in establishing trust, common understanding, working patterns, and different forms of cooperation between stakeholder groups.

Consequently, the ES related to monitoring could eventually be transformed into a voluntary service, meaning that it could survive the decrease or even the disappearance of relative payment [17].

Conversely, maintenance will always require payment but, if this is seen as a fair share of the costs of undertaking this activity, farmers may feel an intrinsic obligation to reciprocate [23] and keep a high standard in executing their tasks.

5.3.2. The Project "Farmers as Custodians of a Territory" in the Theoretical Framework of Payment for Ecosystem Services (PES)

PES schemes related to catchment management are usually more linked to the problems of improving the quality and the availability of water resources for civil and agricultural purposes than to the problem of reducing hydrogeological risk, although we were able to find a few examples (see e.g., [44], box 2, p. 32 and box 9, p. 50).

There are two contributions that directly deal with the interpretation of the project "Farmers as custodians . . . " in the framework of PES schemes.

Leonardi [69] reads the project in the framework of Wunder's approach [22] as a market-based or market-like mechanism; however, we agree with Farley and Costanza [23] when they say that taxes or mandatory service charges are non-voluntary approaches. According to these authors, PES can play an important role in provision of ES, but it can only address the issues of non-rivalry and inherent non-excludability to the extent that it differs from conventional markets, not to the extent that it mimics them [23] (p. 2064). Since there are costs to providing ES, non-market PES schemes may be the most just and efficient means to cover them. Payment will require collective institutions representing and capable of collecting revenue from all beneficiaries of the service [23].

Vanni [67] starts from a PES approach similar to that of Wunder [22], and ends with a new model of PES (see Figure 5.8 in [67]) based on co-production. In this new model, processes such as trust building, social learning, information and resources, networking and co-producing knowledge, which are coming from the interaction of service providers and service users, contribute to service co-production. Nevertheless, in the authors' opinion, also this theoretical model needs a further improvement, since it is not only the case of a simple interaction of providers and buyers of an ES. Indeed, this would only account either for a relationship between Land Reclamation Consortium and End users (real estate owners), where the authority is considered the ES provider; or for a relationship between Farmers and Land Reclamation Consortium, where farmers are considered providers of the ES, and the Land Reclamation Consortium the buyer. From this point of view the scheme should be integrated by the consideration of "intermediaries" and "knowledge providers" and of other relevant groups of stakeholders [44]. The definition of PES provided by Muradian et al. [19], in the authors' opinion, could allow for the design of a more complex model of all the relationships between the involved stakeholders.

Last but not least, the project "Farmers as custodians" does not provide only the "well-defined environmental service" of territorial hydraulic monitoring and maintenance according to Wunder [22], but a bundle of services, some of them loosely defined, that improve social benefits, as stated by Farley and Costanza [23]. Inside this "bundle of services" the following could be included: (a) higher economic viability of rural areas; (b) more rational use of territory, without the dualistic division between concentration in urbanized areas and land abandonment that characterizes Val di Serchio; and (c) conservation of a heritage of rural knowledge is at risk of being lost. This consideration, together with the fact that many environmental services provided by good practices of agricultural land management are incentivized by Rural Development Programmes (RDP), should ask for inclusion in RDP measures that could at least partly contribute to projects such as the one of farmers as custodians. Nevertheless, in Tuscany RDP 2007–2013, the project "Farmers as custodians" could only profit for a small amount of resources under measure 226 on "Restoration of the forestry potential and introduction of preventive actions" [72].

Similar initiatives could be financed from the Tuscany RDP 2014–2020 on the framework of Integrated Territorial Plans, under measure 16, which relates to cooperation. Nevertheless, very often the limit in developing such approaches is not the lack of financial resources but the lack of

an adequate cultural attitude, skills and cooperative context needed for an integrated and collective action. These latter "obstacles" are issues that quite often require more time and for investments on immaterial capital, as well as new attitudes from all the involved parties.

The relevance of the local context where a project is implemented could make it difficult to start similar projects in other areas, except in the case that some very motivated people make an effort, since there is the necessity to make many institutions (i.e., Mountain Communities, municipalities and their union, provinces, etc.) to agree and coordinate and to create a proper attitude among all the involved stakeholders.

6. Conclusions

The importance of agriculture is very often referred to only in terms of its low share of national GDP. Nevertheless, through multifunctionality, agriculture has a great deal of potential to increase community well-being, e.g., through the provision of important Ecosystem Services. This is clearly highlighted by the results of the project "Farmers as custodians of a territory" presented as a case study in this paper.

This paper highlights that addressing the problem of hydrogeological hazard prevention mainly through command and control approaches, as has been done until now, or by Payments for Ecosystem Services (PES) schemes gathering financial resources from taxpayers and using them according to a top-down approach, are not the most cost-effective approaches. Due to the complexity of the problem and the necessity of a collective responsibility in achieving a more resilient situation, it is important to create better awareness of the importance of territorial management among all the relevant stakeholder groups and to promote collaborative approaches. Furthermore, an increasing awareness of the way Land Reclamation Consortia are utilizing public resources and of the results reached in terms of protection of a territory from hydrogeological hazards may improve the willingness to pay of the real estate owners (and taxpayers) and increase their involvement in good maintenance of the hydraulic network on their farms.

From this point of view, despite the positive results of the project "Farmers as custodians," some of the ongoing processes could make it difficult to enlarge and export this pilot experience to other areas. Among these processes are the following: (a) the Land Reclamation Consortia enlargement and estrangement from farming members, which may favor technocratic and top-down approaches; (b) the increasing difficulty for farmers in complying with procurement and e-procurement rules, since many of them are not familiar with information technology; and (c) the reductionist approach of some PES schemes that consider only single and well-defined ES rather than the whole bundle of ES in the framework of a simple relationship between buyer and provider.

Indeed, there is the need for deeper awareness of the role that farmers can play in the community in addition to enhancement of participative approaches that can promote the multifunctional development at the rural territorial level through a strategy of revaluation of local natural and human capital. This calls for an innovative way of thinking and for the adequate normative and policy framework able to promote it. While further studies on the technical, socio-economic and institutional issues related to the problem of hydraulic protection of a territory and consequent prevention of hydrogeological risk are required, it is the authors' opinion that the current Tuscan—and Italian—situation requires recovery of all possible margins of effectiveness and efficiency that can be gained in the short time. In this context, projects with a pragmatic and innovative approach like the project "Farmers as custodians" may significantly contribute to this aim. Nevertheless, further studies focusing on the relations between providers and beneficiaries of ES, and on the role of all the institutions and processes that could influence the effective and efficient provision of ES by farmers, are needed in order to spread such an innovative approach.

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Abbreviations

The following abbreviations are used in this manuscript:

DEFRA	Department for Environment, Food and Rural Affairs (UK)
DSS	Decision Support System
EEA	European Environmental Agency
ES	Ecosystem Services
EU	European Union
FD	Flood Directive
GDP	Gross Domestic Product
GIS	Geographic Information System
IEEP	Institute for European Environmental Policy
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale (Italian National Institute for Environmental Protection and Research)
ISTAT	Italian National Institute of Statistics
LFA	Less Favored Areas
Lgs.D	Legislative Decree
m.a.s.l	Meters Above Sea Level
MATT	Ministero dell'Ambiente e della Tutela del Territorio e del mare (Italian Ministry for the Environment, Land and Sea)
MC	Mountain Community (consortium of communes/municipalities in mountain areas)
MFA	Multifunctional Agriculture
OECD	Organisation for Economic Co-operation and Development
PES	Payment for Ecosystem Services
RDP	Rural Development Programme
WFD	Water Framework Directive
WWII	Second World War

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