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Policy Measures for Ecosystem Services: a first survey of the impact of "Floor and Trade" mechanism at farm level in Veneto

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Abstract

In the ongoing debate of CAP reform, a new tool was proposed for farms that aims to create a new market for ecosystem goods and services that may be provided by agriculture. The mechanism of floor and trade (FT) assigns each holding a "minimum of environmental goods" that must be provided at farm level to ensure sustainability and justifies the subsides received from CAP. In this proposal we will analyse what might happen in a limited region (Veneto) with the application of FT mechanism, given the geographical conditions and the structural situation of farms, using FADN data. More precisely, we seek to quantify the regional supply curve of environmental services, provided by agricultural activities in case of floor and trade mechanism. We will use as a proxy the amount of carbon that could be sequestered by less intensive farming systems such as grassland and pastures, compared with other more intensive activities, in order to examine the trade-off between the economic goals of farmers and the environmental benefits due to the land use change provided by FT. We will use as methodology the Minimum Data (MD) approach in order to integrate the spatial heterogeneity of the biophysical environment of the different agroecosystems, with economic behaviour of farmers in case of the obligations imposed by the FT mechanism

Keywords: Floor and trade, Ecosystems service, FADN.

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1. INTRODUCTION

The identification of policy measures with a good level of cost effectiveness has become a priority issue in the debate on future scenarios for agriculture and rural development. Within the framework of agri-environmental policies, several analysis and proposals have tried to identify new tools to ensure the provision of environmental goods and services at reasonable cost to society as a whole. In short the actions proposed are 1) proportionate incentives to achieve measurable environmental results, 2) provide access to farmers who provide greater environmental outcome, or that require less compensation for the same environmental objective, 3) to apply additional taxes on the use of potentially polluting products, 4) to create new markets through tradable permits (Cooper et al., 2009). The latter category includes the "floor and trade" mechanism (FT) that will be discussed in this paper. The FT mechanism, essentially allows to assign a minimum rate of ecosystem service (ES) that the farms are obliged to provided. In this manner it is possible to justify any public support received from govern for agriculture (Povellato, 2010). The minimum quantity of ES may be represented by a share of the agricultural area devoted to specific farming systems (e.g. permanent grassland), more eco-efficient, for example in CO2 sequestration in agricultural soil (Soil Organic Carbon - SOC) (Vleeshouwers and Verhagen, 2002; Freibauer et al., 2004; Sousanna et al., 2004). This scheme, allows each farm to provide environmental good or to buy the share of public goods from other farms that have any surplus, according to their convenience.

In this paper we examine the likely general implications that might result from application of policy mechanisms designed to emphasize the production of ecosystem service in the case of an Italian region (Veneto). This considering the particular geography of the area and the structural situation of farms emerged from knowledge of the FADN database. The analysis uses as a proxy for ecosystem services, the amount of carbon sequestered from the atmosphere through less intensive farming systems, such as meadows and grazing (MG) with other cropping system more intensive, as arable land. The article is divided into two main sections, the first analyze the potential regional supply curves of carbon sequestered in the hypothesis that all regional farms are oblige to allocate a minimum farmland to meadows and grazing, with a specific direct payment. In the second section, after explaining to short lines the FT mechanism, it is assumed that the obligation to allocate farmland to meadows and grazing, regards only farms that do not reach a minimum threshold, with the possibility to activate or not mechanism permits tractable (floor and trade), considering the potential impact of the implementation of the FT in Veneto. The common assumption to express opinions of convenience comes from the spatial distribution of opportunity costs, from which is possible to derive the potential supply of carbon sequestered by using the minimum data approach theorized by Antle and Valdivia (2006). In this way we can compare the main economic, environmental and social results associated with respective case study and we can evaluate ex ante the best performance of design of specific policies that emphasize the production of ecosystems service from agriculture.

2. THE APPROACH OF MINIMUM DATA TO SIMULATE THE SUPPLY OF ECOSYSTEM SERVICE

The "ecosystem services" has defined as *the conditions and processes through which natural ecosystem, and the species that make them up, sustain and fulfill human life* (Daily 1997). The Millennium Ecosystem assessment has classified the ES in four categories: provisioning, supporting, cultural and regulating services. (Zhang *et al*., 2007). Examples of ecosystem services could be the detoxification of harmful molecules (e.g. phytoremediation), the air and water purification, soil fertility, climate mitigation, natural pest control, etc… (Salzman *et al*. 2001). Agriculture can be an activity that produces ecosystem services, particularly for direct action that has the use of land resource (Antle, 2007). From this point of view the ES are public goods, justifying public policy aimed at increasing their production. In purely theoretical line, an efficient agri-environmental policy should be directed to increase the amount of ecosystem services, trying not to foreclose the agricultural production, by imposing changes on the practice of management. The total suppression of the production, in fact, maximize the value of the resource only if the marginal reduction in the value of ecosystem services is so great as to offset the loss in the market for products (Antle, 2007). Finally, another interesting aspect to an efficient policy should take into account the spatial heterogeneity, because the ES are site-specific and are linked at peculiar features such as land, climate, distance to market, etc. As already stated, in this first step of study, we consider the supply of ecosystem service provided from agriculture related at the amount of atmospheric carbon sequestered in agricultural soils, considering that this service is a function of various parameters site-specific, as well as soil type and vegetation cover, cultivation practices exercised, topography, history of land use, microclimate, etc. We present a case study and assume that given two alternative cropping systems, intensive arable crops (s_1) and meadows and grazing systems (s_2), the transition from one system to another implies theincrease of the amount of carbon stored in soils. More precisely in case of MG, the carbon sequestered is significantly greater than that of intensive arable land[1]. Antle and Valdivia (2006) have introduced an interesting and simple method to estimate the approximate value of the expected supply of ecosystem service provided/suppliable by agriculture. More precisely, the authors propose a *minimum data approach* (MDA), which calculates the supply of ES in a given region by combination of site-specific biophysical aspects with more general information on economic aspects of agricultural systems. We consider that each production system allocates a specific production of ES, and we assume that increase in ES supply involves the conversion toward most eco-efficient system, implying a specific opportunity cost for each choice management. From the spatial distribution of these opportunity costs will then be possible to derive the expected supply of ES. In this paper we try to apply an empirical analysis based on the MDA described in Antle and Valdivia (2006) and developed in several other recent work (Claessens *et al*. 2009; Noalukenge *et al*. 2009; Stoorvogel *et al*. 2009; Antle *et al*. 2010). We will estimate the potential supply of carbon sequestered in the Veneto achievable with ratification of mechanism that involves the obligation of every farms in Veneto, to cultivate a minimum area of MG in order to increase the ES. This first approach is based on a static analysis that estimates the proportion of farmers participating in this mechanism in terms of hectares converted to MG by the original land use at intensive crops, under possible mandatory thresholds of surface (e.g. 5% or more of UAA) in presence or absence of specific incentives[2]. In the initial situation the choice whether cultivates arable crops or MG (s_1 or s_2) depends on profitableness of alternative land uses. For simplicity in this step we assume that there is no additional cost to switch from one to another agrosystem[3]. On this basis the farmer will choose the arable system or MG

[1] The functional relationship between amount of carbon and soil type is generally non-linear and depends on a number of other biophysical parameters, however, for simplicity we consider a linear relationship (Antle, *et al*., 2003).

[2] It is clear that effective participation at the mechanisms is influenced by many other aspects due to behavioral factors, risk perception, age and education of farmers, etc... (Paustian *et al*., 2006).

[3] In general, the additional costs may be different in the transition from one system to another, being the costs of adjustment for capital investments, learning costs of alternative management practices, various transaction costs, as well as issues directly related to behavioral and institutional factors that influence the willingness of farmers to change land use (Fuglie and Kascak, 2001; Sunding and Zilberman, 2001). In addition, if the processes that govern the supplying of ecosystem services are spatially dependent, the more efficient provision may require cooperation between different groups of farmers which is also coordination costs. This costs depends by other factors such as the number of farmers participating, the amount of surface area, etc.. In all these cases the additional costs should be considered in the computation of opportunity costs.

system in function of return per unit (e.g., gross incomes per hectare). In an application context of increasing of the ecosystem services supply, in agriculture could have a direct impact on farmers related to changes in productivity. In these cases, the absence of policies that provide specific incentives would encourage the provision of ES only by farms that find profitable farming MG (e.g. livestock farms). The share of ecosystem services is thus associated with the provision of market goods and does not take into account the assessment by the society. This situation characterizes a "private equilibrium" of ES supply and only an appropriate intervention (e.g. payments offered to farmers) could allow its reconfiguration to enable increasing of the ecosystem services (Nalukenge *et al*., 2009)[4].

In analytical terms the private equilibrium is therefore based on maximizing expected profits expressed by $v = (p, g, s)$ where p is the vector of output prices, g is the geographic location and s is the index comparison of the agrosystems (i.e. s_1 for intensive arable land and s_2 for meadows and grazing), and the management decision will be taken on the basis of opportunity cost for each farm considered

$$oc\ (p, g) = v(p, g, s_1) - v(p, g, s_2) \tag{1}$$

In fact, if $oc \geq 0$ will be chosen to allocate land to intensive crops, and vice versa to MG. By extending the analysis to all the farms in the regions spatially defined, which in the case study in question relate to the provincial areas of the Veneto, can be determined the spatial distribution function (density function) of the relative opportunity costs at a given price:

$$r(p) - \int_{-\infty}^{0} \varphi(oc)\ doc \tag{2}$$

where $0 \leq r(p) \leq 1$ is the share of land for private equilibrium in MG activity (Antle and Valdivia, 2006, Antle *et al*., 2010). From this function can be derived the expected value of the overall regional supply of ES [S (p)] in a given period (one year in this case study) and in a given area of H hectares:

$$S(p) = r(p)H\ e(g) \tag{3}$$

where $e(g)$ represents the amount of carbon sequestered annually by the atmosphere and stored in the agricultural soil when is occupied by meadows and grazing systems for each local situation considered[5]. Assuming now the existence of a measure that encourages farmers to increase the supply of ES, such as represented by the additional payment per unit of ES product (p_e), can be configure a new equilibrium and the equation (1) becomes:

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[4] Some processes that determine the provision of ecosystem services like carbon sequestration in agricultural land, are spatially independent while others, such as biodiversity or water quality, can be spatially dependent. It is important that in these cases, as noted in Nalukenge *et al*. (2009), are taken into account these spatial dependencies in the design of an efficient mechanism for providing the same services. The problem of spatial dependence also arises for opportunity costs when there are positive externalities such as learning associated with the adoption of alternative management practices.

[5] For simplicity in this paper we assume that amount of carbon sequestered in different only to the type of land use and is constant throughout the region. The reference values are funded on the study by Vleeshouwers and Verhagen (2002), which we refer for details.

$$oc_{ES}\,(p,g) = v(p,g,s_1) - [v(p,g,s_2) + p_e e(g)] \quad (4)$$

The (4) indicates that the choice of farmers to convert intensive arable land to grassland occurs if and only if $\mathbf{oc_{ES} < 0}$. Considering the spatial distribution of opportunity costs in the presence of specific incentives expressed as price p_e will find that

$$r(p,p_e) = \int_0^{p_e} \varphi(oc)\,doc \quad (5)$$

where $\mathbf{r(p,p_e)}$ represents the range of hectares of land allocated to MG when the opportunity cost is between zero and $\mathbf{p_e}$. The expected value of the supply of ES will be

$$S(p,p_e) = S(p) + r(p,p_e)He(g) \quad (6)$$

which represents the total amount of ES corresponding to the range of incentives $\mathbf{p_e}$. The value of this function is the sum of all units of service produced (tons of carbon sequestered) on the additional land units converted from intensive arable land to meadows and grazing systems. The properties of the curve $S(p,p_e)$ are determined by the shape of the density function of opportunity costs and the quantity per unit of ecosystem services provided (Antle *et al.*, 2010).

In farming context, therefore, three cases may occur in the formation of ES supply: 1) $\mathbf{oc < 0}$, so the allocation of MG area is preferred to arable land without specific incentives, 2) $\mathbf{oc_{ES} < 0}$, arable land are cheaper than MG and then the conversion of land use is only in the presence of an incentive, 3) $\mathbf{oc \geq 0}$ and $\mathbf{oc_{PES} > 0}$, the intensive crop system are always cheaper than MG for the entire range of expected payments. Assuming a range of payments per unit of ES products, the analysis was repeated for each value derived from the corresponding expected values of land converted to MG and then potential supply of ecosystem services distinct in provincial zone. The slope of the curve obtained is positive, because for each specific increases in incentives there is an increase of farmers willing to participate in such contracts, according to the technical potential of their land and opportunity costs incurred (Antle and Stoorvogel, 2006).

3. THE "FLOOR AND TRADE" MECHANISM

The FT mechanism has been proposed for the first time by the *Country Land and Business Association*, a British organization that represents large landowners (CLA, 2009) and subsequently taken up by the RISE Foundation (2009). In essence, this mechanism provides a minimum quantity of environmental goods that must be provided from the farms, through the assignment of obligations to ensure the sustainability of productive activities. Of course, these environmental goods that the farms could produce, are currently provided meagerly and perceived as scarcest and needful from the society, because could strike a better balance of the ecosystem. The "minimum quantity" of these goods could take the form of a share of the agricultural area devoted to permanent grassland, hedges or a certain amount of CO_2 stored in soil or biomass.

In the case of meadows and grazing systems (MG), these represent the most extensive form of forage farming. These cropping systems are often confined to areas not much indicated to other agricultural uses or where are emphasize the environmental and landscape aspects. The MG play important ecological roles linked at the fact that they are dynamic and complex natural systems and reach ahigh degree of biodiversity reached for many species of plants living in balance with the mineral substrate. In particular, these systems are characterized by their ability to sequester atmospheric CO_2 and store it directly in soil. As reported in the literature, to the soil occupied by permanent forage systems in Europe, an average estimated annual of 0.52 tons of carbon stored per hectare, compared with -0.84 tC/ha^{-1} y^{-1} in intensive arable lands (Vleeshouwers and Verhagen, 2002)[6].

On this basis, implementing the FT mechanism, each farm would be free to decide whether to directly provide the good environment (MG land) or to buy that share of public goods from other farms that have a surplus if the other land-uses for productive activities are more profitable. The introduction of this obligation associated with the possibility of trading with other farms creates a new market for environmental goods and services that may be provided by agriculture. When the amount of a given environmental good available to a company exceeds the required minimum amount (*floor*) a "credit" is generated that can be traded (*trade*) with farms that, under the intensive and specialized production, need to comply with the minimum requirement. The elasticity of the system respect to a mandatory requirement could allocate the production activity of environmental goods on the basis of their opportunity cost. So should be achieved (in theory) more efficient allocation.

This mechanism is similar at "*cap and trade*" measure provided in recent years for the emissions of greenhouse gases by some industrial sectors in Europe (*Emission Trading System*) that has been implemented since the seventies in the United States about air pollution act. To enable a market for tradable permits require the following minimum requisites: 1) there must be a surplus of tradable goods; 2) must be legally applicable; 3) must be permanent; 4) the environmental goods must be quantifiable (Tietemberg, 2004). The measurability of the good subject of FT mechanism is particularly important for agricultural activity that has external effects (positive and negative) common and not easily quantifiable such as in industry. The quantification of the environmental good is given by the area occupied by these land uses, possibly related to comply with certain standards of management. An example of this type of obligation is the "*ecological compensation areas*" or "*ecological priority area*" introduced a few years in Switzerland as part of compliance. In this case the farmers are required to keep a rate of their land as ecological compensation areas as a condition to receive direct and ecological support payments (Cooper *et al*., 2009, p. 134). In facts, the Swiss farmers are required to show that the company has a certain percentage of land for ecological compensation (7% or 3.5% of

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[6] These values are based on the results obtained by applying the simulation model CESAR (*Carbon Emission and Sequestration by Agricultural Land Use*) developed in Vleeshouwers and Verhagen (2002). The model is based on a system of carbon balance, which computes in addition to the inputs of carbon in plant biomass due to photosintetic process, also output of organic matter accumulated in the soil in quantities related to site-specific soil and weather conditions.

UAA in the case of special crops), which include extensive permanent grassland, hedges, woods, small areas wetlands, trails, stone walls and extensive orchards. The 120.000 hectares, or 12% of the UAA, are represented by three quarters by extensive meadows. Several European environmental organizations have suggested that the ecological priority areas should be also included among the environmental standards that farmers must comply with EU countries (BirdLife, 2008). Actually, it seems that there is a gradual recognition of the need to preserve natural habitats on farms by the European legislation. First, the meadows and grazing lands have been included since the reg. EC 1782/2003 of the compliance requirements, and confirmed with the reform of the Health Check. The article 6 of Reg. EC 73/2009 reaffirming the mandatary of farmers of Member States to maintain at least the extension of MG in 2003. Moreover, among the mandatory requirements of compliance provided by the regulation, there is an obligation to maintain the "landscape features, including, where appropriate, hedges, ponds, ditches, trees in rows, in groups or isolated and margins fields" and one of the optional requirements has been included as the "creation and/or preservation of *habitat*". In Italy, for example relating to the mandatory elements characteristic has been further identified and strengthened in 2010, while the option of habitats has not been taken into account. On this basis might be reasonable to assume that environmental standards for biodiversity will have an increasingly important role, especially if it reestablishes the ecological network composed of semi-natural elements and areas under permanent grassland, which in recent decades have undergone a dramatic reduction in Italy as happened as in other areas of Western Europe (Farmer *et al*., 2008).

Considering the need to increase the supply of ecosystem services provided by agriculture, we could envisage an obligation for every farm to identify areas of ecological priorities at least equivalent to a minimum (e.g. percentage of UAA at 5%, 10% and 15%). In these cases, the FT mechanism could be used, even temporarily, to allow at farmers to identify the most appropriate solution in terms of allocation of the land factor and to ensure that this obligation would affect too much in farm income. The definition of the threshold values is crucial not only to create the conditions for the exchange of permits, but also in terms of cost effectiveness of the measure. In fact, the increase in costs (private) incurred by the farmers - both in cases of direct application to the purchase of credits - it should take account of environmental benefits (social) achieved in rural areas. The measurement of these benefits opens up a scenario where the environmental economist are questioning a long time giving rise to interesting and controversial discussions on the theme of climate change, beginning with the Stern Review (2007), and more recently also in terms of biodiversity (TEEB, 2009). Another rather important aspect in the choice of a mechanism for applying FT covers the area within which it is possible trade credits. As already noted in the case of cap and trade applied to specific cases of pollution should not be allowed farms that are located in protected areas or high natural value of being able to compensate for the lack of "ecosystem services credits" with other farms that are outside of these areas. Equally important is the choice of the size of areas that, if very large may allow substantial reallotments (mountain areas with the most credits offset the more intensive lowland areas), while a greater segmentation would lead to a better distribution of ecosystem services (for example, requires states that a certain threshold must be met within the lowland areas). These last two examples are not neutral in terms of environmental effects achieved and therefore should be carefully considered the effects that different applications of the FT mechanism could have on environmental quality of areas. Finally, from an economic point of view, in the presence of a mechanism of FT, a farm decides to fulfill the mandatory only if the difference between the loss of traditional agricultural production income and the opportunity cost of maintaining these ecological priority areas is lower of the cost it would incur in order to acquire this ecosystem service from other farms. Since the ecological priority areas cover a very limited area, it should be assumed that there are no large structural changes and then there is no change in fixed costs. This leads us to believe that the gross income is the variable most appropriate. In other words, if there is convenience to purchase credits, the retractable gross income from the crop minus the cost of buying credit from another farm must be greater than the difference between revenues and maintenance cost of ecological priority areas in their own farm.

4. RESULTS OF MINIMUM DATA APPROACH AT THE CASE STUDY

The research was carried out starting from the knowledge of the average carbon fluxes for each farming systems, and the opportunity costs derived as the difference between gross incomes in both activities. The biophysical data on the flows of carbon sequestered by various land uses in Europe have been learned from the results of the CESAR model (Vleeshouwers and Verhagen, 2002; Freibauer *et al.*, 2004; Sousanna *et al.*, 2004), while the economic information necessary to simulate the decisional model have been learned from the FADN sample for the Veneto region, making reference to the year 2007. More precisely the farms sample has been select according to altitude limit of the Veneto plain. The spatial dimension of reference has therefore been created by layering the sample on the basis of belonging to the province of farms creating six groups (Verona, Vicenza, Treviso, Venice, Padua and Rovigo)[7]. As mentioned, in order to limit the analysis to agricultural systems for herbaceous cropping systems to intensive arable land and grassland, the farms sampled include only those with utilizable agricultural area (UAA) devoted to herbaceous. The systems considered were built on two macroaggregates. The first system (s_1) includes acreage for cereal, legumes, industrial crops, vegetables, flowers, alternated fodder and field crops in general[8], while the second system s_2 is based on the UAA devoted to pasture (monophyta and polyphyta) meadows, permanent pasture and pasture-fallow production. For each macroaggregate we computed some economic parameters, such as: the aggregate output for each activity, the quantities sold and the respective monetary values, the variable costs of management (including the expenditure items for seeds, fertilizers, pesticides,

[7] The province of Belluno has been excluded since have not lowland areas
[8] Mushroom farms are excluded.

rental farm equipment, irrigation and other expenses), and reuse of farm output. Following were determined some budget variables to calculate the distribution of opportunity costs related to the sample (characterized by 540 observations)[9]. The variables are the average yields unit, the unit explicit costs, average prices and therefore the overall gross income. Finally were weighted appropriately and extended to the entire population of regional farms considered[10].

In recent years in Italy the meadows and grazing land did not decrease thanks to the decoupling mechanism and the trend of the pre-reform period to cultivate crops in order to receive contribution per hectare has been slowed down. Moreover, the gradual intensification of crop production that promotes a greater potential forage respect to the MG systems remains a latent threat. In fact, in the most fertile plains is becoming very rare to find MG, which are concentrated in marginal areas and have no alternative economically profitable, such as mountain (Povellato, 2010)[11]. But what could be the potential impact in Italy due to the implementation of two different policy measures such as: 1) payments for ecosystem services or 2) introduction of ecological priority areas? In order to answer this question we estimated the possible land surface affected by the introduction of these two policy measures starting from the FADN database and restricting the analysis in Veneto region.

The main assumption regards the requirement for all farms must have a sufficient area to permanent grassland managed according to criteria of good and sustainable agricultural practices. On this basis, in Veneto, limiting the analysis only to the agricultural land devoted to herbaceous crops in lowland, 91% of the farms does not have permanent forage crops, while about 9% have meadows and grazing systems. The farms that adopt MG in their land use plan, devote a large share of the UAA.

4.1. Payments for ecosystem services

The MD approach has been implemented supposing the increases of 5% or more of UAA allocated to MG. The knowledge of the unit values of costs and average yields has allowed us to revise the gross incomes on new configurations of crops and then the opportunity costs calculated as the difference between the first and second system. As explained above, the profitability of two systems can be given from difference of opportunity cost, which are heterogeneous and spatially explicit.

In this step we estimated the opportunity costs, determined the associated spatial distributions function (density function) in Veneto and the spatial distribution of opportunity cost per unit of ecosystem service (tons of carbon sequestered). From this distribution function

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[9] For more details on the formation and structure of the FADN data see Abitabile and Scardera (2008).

[10] In reality more than the population of firms would be appropriate to speak of individual cropping systems, given the selection operation that has limited the analysis to only two types of productions that fall in one area of difference.

[11] According to the latest ISTAT survey on the structure and production of farms in 2007, in Italy the areas of meadows and grazing are concentrated at 86% of the total UAA in mountainous and hilly, while the plains are represented only 7% with a clear trend to decline in recent years. In general, MG lands are in farming with livestock or land public bodies (including municipalities and mountain communities), which lease these areas to farm for a few months a year (about 900.000 hectares exclusively in mountain areas) (INEA, 2009; Povellato, 2010).

we derived the potential supply of surface convertible to MG systems expressed in terms of the range of payments per unit of carbon stored in soil. The sensitivity analysis was conducted based on the threshold of payment ranging from 50 to 350 €/t of carbon, with intermediate steps of 50 €/tonne. The results show that in the baseline case (without incentives) in Veneto is really negligible the rate of farms that find profitable switching the producing system at MG, which in terms of surface means little more than 4.000 hectares. In presence of a policy of incentives based on payments per unit of ES provided, the amount of UAA converted to MG increases. Assuming maximum ecosystem service price of 350 € /t, reaches almost 25.000 hectares with an increase from baseline of 480% (Fig. 1). At level of the six selected provinces of Verona, Vicenza, Treviso, Venice, Padua and Rovigo, the results express some very interesting variations, highlighting the strong spatial heterogeneity discussed above. In the baseline case without incentives, participation rates are practically insignificant for Vicenza, Treviso, and Venice, and the rates increase only when ES price becomes 250 €/t. In this case at Treviso the rate arrive about 545 hectares, constant until maximum price; in Venice the increasing is very significant with 3.800 ha, until 7.200 hectares at the maximum price floor, while in Vicenza is zero always. In Verona initially we found that the farms participating with 613 hectares and arrive at almost 5.000 hectares with maximum price, while Rovigo and Padua even if begin with 1.232 and 2.378 respectively, they remain somewhere indifferent at the ES price increasing, except Padua that treble the participation rate with maximum price (Fig. 2).

Figure 1 – Regional land supply at different ecosystem service price

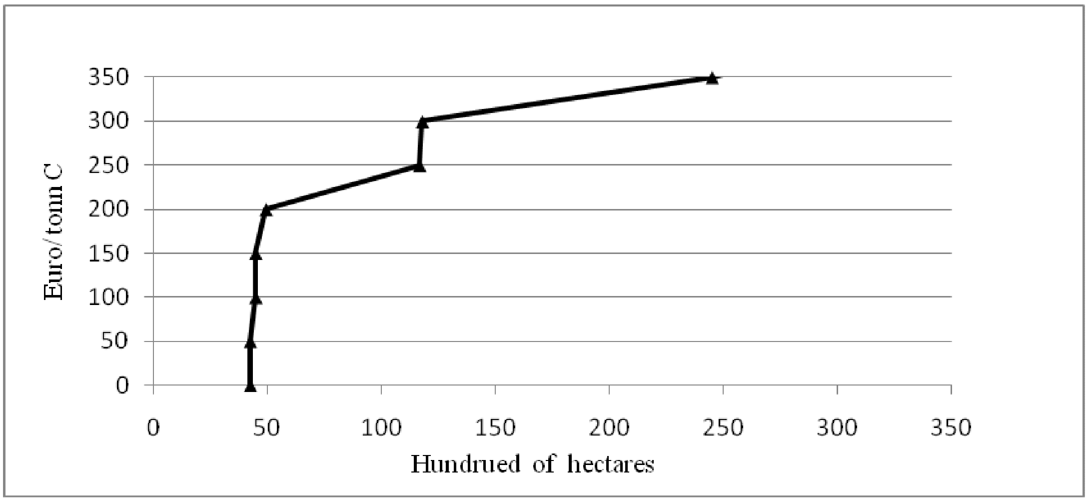
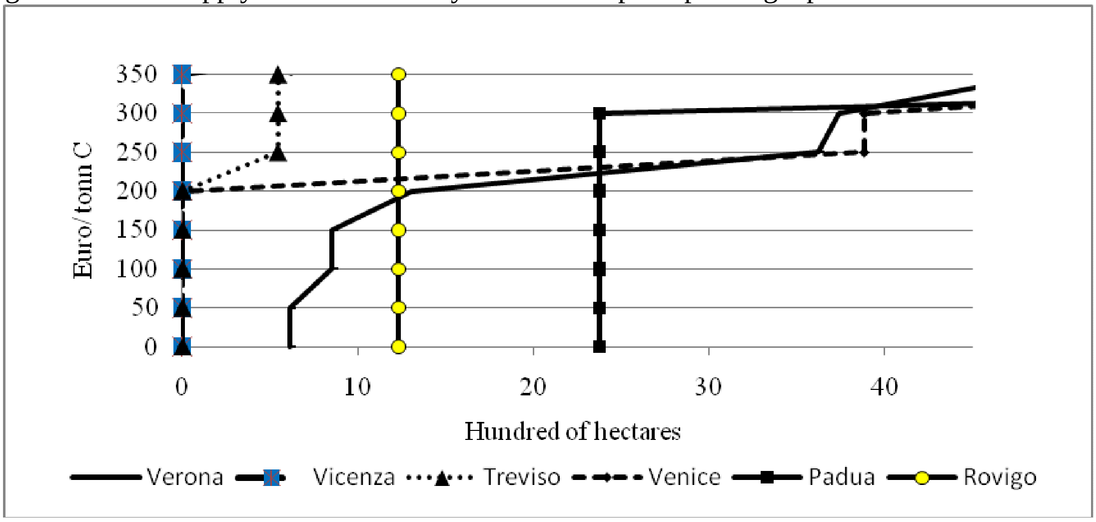


Figure 2 – Land supply at different ecosystem service price per single province.



4.2. The potential impact of ecological priority areas in Veneto

Starting from the FADN data used in the earlier analysis, in this second step we will investigate the impact that the introduction of the other policy measures, the ecological priority areas, under two different policy mechanisms: the mandatory approach and the "floor and trade" approach. The first scenario is the "floor and trade" mechanism that provide the possibility to enable a market of tradable permits of ES, as introduced, which refer to minimal surfaces of meadows and grazing. The second scenario, instead regards the implementation of a simple obligation to change land use towards MG systems. The simulation assume three minimum threshold of MG land required in each farm. We define two alternative scenarios to the baseline.

Minimum farm threshold of UAA at MGL	**First scenario**	**Second scenario**
5%	Floor and trade (FT)	Mandatory
10%		
15%		

As shown in Table 1 in Veneto on a current agricultural utilizable area allocated to arable crops of about 545.260 ha, only 6% is occupied by MG (32.715 ha). This, in general terms means that in the case of FT (as well as mandatory) and a mandatory minimum area of 5% of UAA in MG there is a problem purely redistributive respect to the case of a larger percentage (10% or 15%), where a new allocation is need that provide the conversion in MG for arable land. For this reason we presented the three different thresholds for the two scenarios. Therefore, if the requirements were introduced in permanent grassland cultivation, say 5%, 10% and 15%, respectively, shows the need to convert about 24.000, 48.000 and 72.000 hectares to MG or to request a corresponding proportion of credits (Tab. 1).

Table 1 – Distribution of farms and land area in Veneto through meadows and grazing classes on the herbaceous UAA

MGL classes	Farms number	UAA tot.	AL	MGL	Mandatary share	Potential MGL credit	Potential UAA convertible	
						(ha)		(%)
Minimum threshold 5% UAA at MG								
without MGL	37.272	479.917	479.917	0	23.996	23.996		
MGL < 5% UAA	60	1.256	1.216	40	63	23	*24.019*	*4%*
MGL ≥ 5% UAA	3.755	64.087	31.412	32.675	3.204			
Total	41.088	545.260	512.545	32.715	27.263			
Minimum threshold 10% UAA at MG								
without MGL	37.272	479.917	479.917	0	47.992	47.992		
MGL < 10% UAA	505	10.215	9.455	760	1.022	261	*48.253*	*9%*
MGL ≥ 10% UAA	3.310	55.127	23.173	31.954	5.513			
Total	41.088	545.260	512.545	32.715	54.526			
Minimum threshold 15% UAA at MG								
without MGL	37.272	479.917	479.917	0	71.988	71.988		
MGL < 15% UAA	553	11.331	10.435	896	1.700	803	*72.791*	*13%*
MGL ≥ 15% UAA	3.262	54.012	22.193	31.818	8.102			
Total	41.088	545.260	512.545	32.715	81.789			

Note: AL arable land, MGL meadows and grazing land
Source: our elaboration on FADN data

This simple framework shows that the instrument of floor and trade has some peculiarities that make it attractive in a potential regional introduction, in order to make it less expensive and more acceptable to the transition of farming systems to a greater degree of sustainability.

The purpose of our investigation is to distinguish the convenience of farmers to self-produce MG or directly contact the allowance market. The analysis started substantially from the definition of opportunity costs, in turn accounted for by differences in performance of individual cropping systems in line with what has been seen in the previous section. Moreover, in this case we take into account the transaction costs. Therefore, the choice to allocate land will be given as a function of the individual gross income, transaction costs and minimum thresholds.

$$Ha = f(p, s, g, KT, Tr) \tag{7}$$

where *Ha* are the hectares allocated to MG, while *KT* and *Tr* are respectively the transaction costs and the minimum threshold (floor). For the first scenario, the computation of *Ha* is quite simple because it is basically to redistribute the land uses in order to optimize the presence of MG for each company based on individual economic advantages. On this basis, the farms differ in surplus of MG surface (> 5% UAA) from those in deficit. The latter may decide to convert part of its surface in MG if their opportunity cost is less transaction costs (*OC* < *KT*), otherwise find it profitable to address the market shares of MG (trade). On the other hand, farmes that have potential credit are those that have an area allocated to MG 5% higher, and therefore may decide to "sell" on the market. In economic terms, the implementation of the FT will affect the final income on the basis of any credit/debts. The debts (*DEBT*) are quantized by a deficiency of land for the transaction costs per unit, while the credits (*CREDIT*) are given by the surplus shore for unit transaction costs, and related to the amount of effective debts, net of farms that decide to self-produce. Analytically the balance equation is then given by

$$GI = \sum_{h,s} v\,(p,g,s) + [Credit_{MG} - Debit_{MG}] \tag{8}$$

where *GI* is the gross final income, $v(p,g,s)$ are the returns for each farm unit (*s*) and their relative share of land (*h*). In the alternative scenario, the situation is much easier because it reduces to a reallocation only mandatory for firms in deficit of MG, followed by adjustments of gross income in purely on the returns unit. In the second and third case in which the units arrive at the floor of 10% and 15% the situation is complicated because in the presence of FT the problem is not only primarily redistributive, but also implies the need for a proper reconfiguration of the scheme allocation of land use by providing for the conversion, sometimes full of UAA business. Even in this case the choice of farmers to allocate land to MG can be represented by (7), and they express the opinions of convenience to self-produce or to buy permits on the market. In our survey the farms were separate from those in deficit and surplus of MG according to their mandatory share (floor), while the convenience to convert the land uses or buy (sell) permits was evaluated based on the transition costs.

In order to characterize the opportunity cost to produce intensive crops or meadows and grazing in the presence of FT, and identify the point of equalize between farms in effective debit (ie non convenience to self-produce) and in credit, we determined the land cumulative distribution functions and then we compared for both cases (Figures 4 and 5). Thus was established a sort of "equalize price" (P_{eq})[12] given by the break-even point between the unitary opportunity costs to choose one or the other system in the case of farms that are in surplus and deficit of MG. The significance of this break-even point is to identify the price at which it could become profitable for farms in debit (credit) to buy (sell) permits of use in MG in the presence of FT. According to this scheme the surface due allocable subject to exchange (trade) is the difference between the obligation required (floor) and the requirements needed to satisfy by the reallocation "intrafarm" because the opportunity cost is less than or equal to the equalize price.

This simple framework shows that the instrument of floor and trade has some peculiarities that make it attractive in a potential regional introduction, in order to make it less expensive and more acceptable to the transition of farming systems to a greater degree of sustainability.

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[12] Based on the results of this analysis, the equalize prices are respectively of 490 € / ha in the case of FT to 10% and 750 € / ha in the case of 15%.

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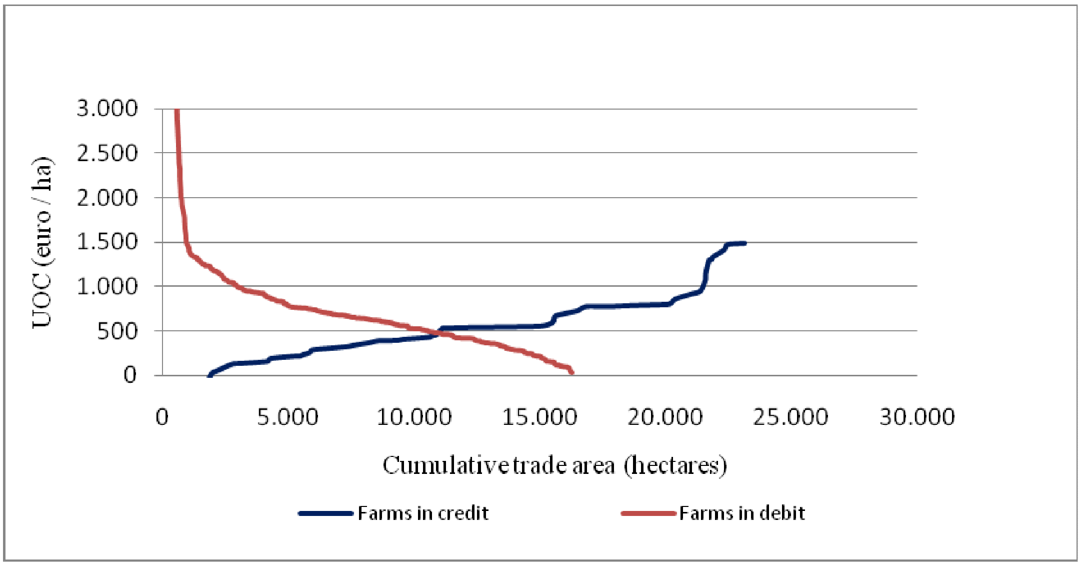
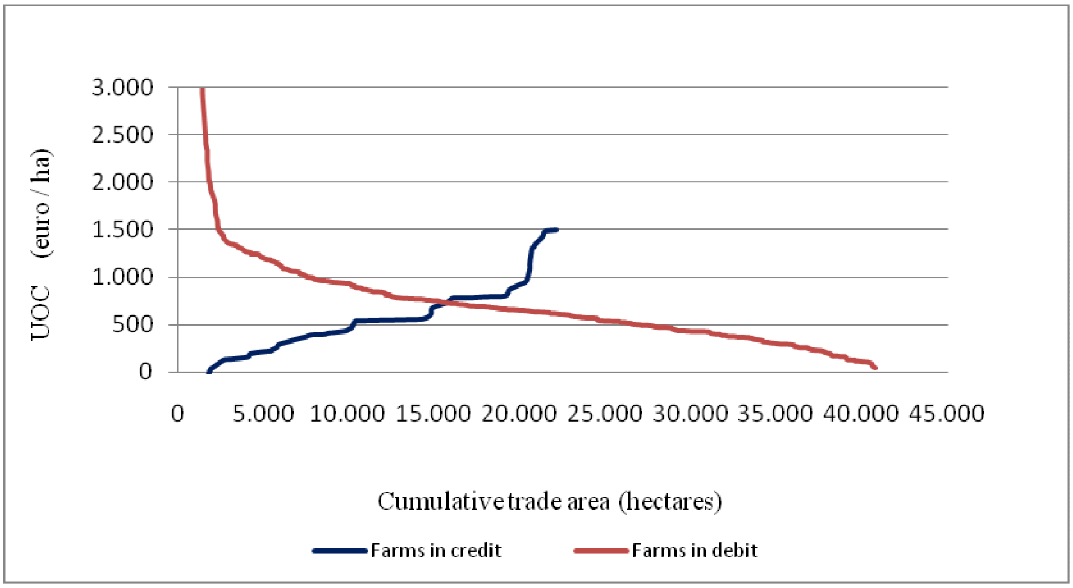
Figure 4 – Relation between unitary opportunity cost (UOC) and trade area in FT mechanism in case of 10% UAA at MG



[13] Based on the results of this analysis, the equalize prices are respectively of 490 € / ha in the case of FT to 10% and 750 € / ha in the case of 15%.

Figure 5 – Relation between unitary opportunity cost (UOC) and trade area in FT mechanism in case of 15% UAA at MG



With regard to effective credit surface, there may be two situations. The first where the opportunity cost is less than or equal to the equalize price, so should allocate all the farmland in MG, while the second, when the price is higher than the break-even opportunity cost, agrees to sell only the MG surplus. Under the new farmland configuration derived from this reasoning, we have determined the economic performance in terms of gross income by applying (8)[14]. At the end of each processing (per scenario and per threshold), the amount of carbon sequestered was computed, according to the coefficient explained in the previous paragraph.

Table 2 shows the main effects obtained from the analysis, separately for each scenario and each share of the amounts in debit and in credit of MG surface, with prospective economic results achieved by implementing one or the other political mechanism. In particular, we observe that in the case of FT changes in income for the farms in debit are practically negligible, while the situation for those in credit could bring significant improvements in achieving income gains estimated between 8% and 15% respectively for the second and third case (10% and 15%). By comparison with the second scenario is known as the possible losses are more

[14] In this case the relative amount of debt and credit were quantified according to the costs of transition and equalize price. More specifically, the share of total debt is given on the bases by the reallocation intrafarm: $Debt_{in} = (DEFICIT)\frac{\sum_g SURPLUS}{\sum_g DEFICIT}KT$; and from debt share that can be filled only by permits market, because reallocation is less profitable: $Debt_{out} = \left[Tr - \left(Tr\frac{\sum_g SURPLUS}{\sum_g DEFICIT}\right)\right]P_{eq}$. Similarly for the credit, their proportion includes both those already available within the farm: $Credit_{in} = (SURPLUS)\ KT$; and the potential credit determined by the farmland not allocated to MG but could agree, $Credit_{out} = (UAA - MG)\ P_{eq}$.

substantial, though limited and less than 10%. This outcome confirms that the introduction of tradable permits based measures as floor and trade mechanism, are innovative tools designed to emphasize the agricultural production of ES, but at the same time guaranteeing the income of farms in this way and seeking "*win win*" solution. The situation changes radically when we consider the amount of ES provided (Tab. 3). In this case the differences between the net flow of carbon are more pronounced. In fact, if the threshold of 5% to an improvement estimated at 8-9% in both scenarios, the possible increase in surface obligation involves considerable differences that that favor the scenario mandatory. In the case of threshold to 10% of UAA, the carbon sequestered attains almost 20%, compared with only 7% of the FT mechanism (even lower than the first level). The increase to 15% of UAA instead results in an improvement of up to 30% for the second scenario, compared with 20% in the first.

Table 2 – Results on three scenario on baseline, floor and trade and mandatory

				Baseline		**Floor and trade scenario**				**Mandatory scenario**			
	Threshold	Farms number	MGL mandatory share (ha)	MGL (ha)	Gross farm income (mill. euro)	MGL *ex-post* (ha)	Gross farm income (mill. euro)	Change inc. base. (mill. euro)	Percentage change baseline	MGL *ex-post* (ha)	Gross farm income (mill. euro)	Change inc. base. (mill. euro)	Percentage change baseline
Farms in debt	*5%*	37.332	24.059	40	793	2.768	794	0,1	0,0%	24.059	770	-24	-3,0%
	10%	37.777	49.013	760	806	11.093	800	-6	-0,8%	49.013	759	-47	-5,9%
	15%	37.826	73.687	896	807	34.897	786	-22	-2,7%	73.687	736	-72	-8,9%
Farms in credit	*5%*	3.755	3.204	32.675	65	32.675	65	1	1,0%	32.675	65	0	0,0%
	10%	3.310	5.513	31.954	52	42.818	56	4	7,8%	31.954	52	0	0,0%
	15%	3.262	8.102	31.818	51	47.580	58	7	14,7%	31.818	51	0	0,0%
Total	*5%*	41.088	27.263	32.715	858	35.442	859	1	0,1%	56.733	834	-24	-2,8%
	10%	41.088	54.526	32.715	858	53.911	856	-2	-0,2%	80.968	810	-47	-5,5%
	15%	41.088	81.789	32.715	858	82.477	844	-14	-1,6%	105.506	786	-72	-8,3%

Table 3 – Comparison of carbon net flow between floor and trade and mandatory scenario for each threshold of UAA at MG

			Floor and Trade				Mandatory			
	Threshold	Carbon flow *ex-ante* (000 tonn)	Carbon flow *ex-post* (000 tonn)	Carbon net flow (000 tonn)	Perc. change	*Gross income/C. net flow (€/ tonn)*	Carbon flow *ex-post* (000 tonn)	Carbon net flow (000 tonn)	Perc. change	*Gross income/C. net flow (€/ tonn)*
Farms in debt	5%	-404	-400	4	1%	25	-371	33	8%	-724
	10%	-411	-397	14	3%	-438	-345	66	16%	-723
	15%	-411	-365	46	11%	-466	-312	99	24%	-723
Farms in credit	5%	-9	18	27	292%	23	-9	0	0%	0
	10%	-3	12	15	519%	274	-3	0	0%	0
	15%	-2	19	21	1022%	346	-2	0	0%	0
Total	5%	-414	-382	31	8%	23	-381	33	8%	-724
	10%	-414	-385	29	7%	-73	-348	66	16%	-723
	15%	-414	-346	68	16%	-209	-315	99	24%	-723

5. CONCLUDING REMARKS

The ecosystems service provided from agriculture are classified by the recent Millennium Ecosystem Assessment, and depend in turn upon a web of supporting and regulating inputs to production (e.g., soil fertility and pollination). Agriculture also receives ecosystem dis-services that reduce productivity or increase production costs. Managing agricultural in a way to provide sufficient supporting and regulating ecosystem services and fewer dis-services will require research multidisciplinary and collaborative (Zhang *et al*. 2007). In this paper we focalized how ecosystem services can be managing across a particular form of tradable permits, the floor and trade mechanism, and we noted that this policy are more efficient and effective than policy based on direct payments or direct mandatory. In particularly we have explored a case study oriented at comprehending the potential impact at the farm level of introduction of floor and trade mechanism in precise farming context. We find that a more efficient mechanism is based on tradable permits, because this mechanism propose a win-win solution, observing both interest of farmers and society. On the other side, the largest provider of ecosystem service (carbon sequestered) has achieved with mandatory mechanism.

The overall results show that, even without payments (first step), a certain percentage of the farmers already adopt unknowingly the practices more eco-efficient, providing certain ecosystem service. The key question that remains is the assessment of proper transaction and adoption costs (Stoorvogel *et al*., 2009). These costs may have a significant impact on the interpretation of the results and we tried a possible accounting (second step). In FT scenario, farmers that attain low opportunity costs have an incentive to producing ES because they can sell the resulting permits on the market, while farmers on which MG activity is expensive have an incentive to maintain alternative and intensive cropping systems and may prefer buying permits for compensation. Hence, in principle, permit markets provide an incentive for landowners to use their land in such a way that a cost-effective allocation of land-use types emerges. In fact, because carbon can only be release if carbon of equivalent value is stored, the ecological effectiveness of the instrument is ensured. There are many potentialities from FT system. In fact the supply of permits may come from private farmers but also from state authorities and conservation groups in possession of land. Ecological consultancies may also buy land to dedicate providing ecosystem services or cooperate with other farmers (Wissel and Watzold, 2010).

The starting point of the case study is the spatial distribution of opportunity cost, the ecosystem services measured with carbon sequestered in function of different land uses and the reference at FADN database. Obviously, in this approach there are many weaknesses linked at the uncertainty of effective quantity of carbon sequestered (that depending strictly from various site-specific parameters, which soil type and vegetation cover, cultivation practices exercised, topography, history of land use, microclimate), the data accuracy, the price vector of output, the different farmer's behavior, the livestock presence, etc.. However, this study is just a first survey of the impact at farm level, which shows some details of the proposed instrument of "floor and trade" that make it attractive also in Italy in order to make more acceptable the transition of agricultural systems towards a greater degree of sustainability. Certainly the implications of the design application (threshold values, defined areas, aspects of redistribution, the impact on business costs, etc..) has to be studied more in depth. But it should be emphasized that the FT mechanism has been proposed by an organization close to the farmers, very active in seek solutions "win win" that achieve environmental goals while assuring the income of farms and simplify administrative procedures (CLA, 2009). In other words, these proposals should not be exclusive patrimony of environmental organizations, but may also find acceptance in agricultural sector (e.g. professional organizations), emphasizing the right size and convenience of environmental policies. There are still many aspects that need to be explored and which may serve as evidence of start for further study, so for example the possibility to analyze in advance the implications of these innovative mechanisms for public intervention. In Italy the current availability of data from statistical sources (FADN, ISTAT census and sample surveys) or from administrative sources is such that many studies may already be made.

REFERENCE

Abitabile, C., Scardera, A. (2008), La rete contabile agricola nazionale RICA, INEA, Roma.

Antle, J. M. (2007), Payments for Ecosystem Services and U.S. Farm Policy, In: The 2007 Farm Bill and Beyond: Summary for Policymakers. American Enterprise Institute Agricultural Policy Series, AEI Press. Washington, (available on: http://www.aei.org/docLib/20070515_antlefinal.pdf)

Antle, J. M., Valdivia, R.O. (2006), Modelling the supply of ecosystem services from agriculture: a minimum-data approach, The Australian Journal of Agricultural and Resource Economics 50.

Antle, J.M., Diagana, B., Stoorvogel, J.J., Valdivia, R.O. (2010), Minimum-data analysis of ecosystem service supply in semi-subsistence agricultural systems, Australian Journal of Agricultural and Resource Economics, 54 (4).

Antle, J.M., Stoorvogel, J.J. (2008), Agricultural carbon sequestration, poverty, and sustainability, Environment and Development Economics, 13 (3).

BirdLife (2008), BirdLife International's response to the Commission public consultation on the Issues Addressed in the "Health Check" Communication, BirdLife International, Brussels.

CLA (2009), Private solutions to public problems, Developing environmental markets, Country Land and Business Association, London.

Claessens, L., Stoorvogel, J.J., Antle, J.M. (2009), Ex ante assessment of dual-purpose sweet potato in the crop–livestock system of western Kenya: A minimum-data approach, Agricultural Systems 99.

Cooper, T., Hart, K. Baldock, D. (2009), The Provision of Public Goods Through Agriculture in the European Union, Report Prepared for DG Agriculture and Rural Development Contract No 30-CE-0233091/00-28. Institute for European Environmental Policy, London.

Daily, G.C. (eds.) (1997), Nature's Services: Societal Dependence on Natural Systems. Island Press, Washington.

Farmer, M., Cooper T., Baldock, D., Tucker, G., Eaton, R., Hart, K., Bartley, J., Rayment, M., Arblaster, K., Beaufoy, G., Pointereau, P., Coulon, F., Herodes, M., Kristensen, L., Andersen, E., Landgrebe, R., Naumann, S., Povellato, A., Trisorio, A., Jongman, R., Bunce, B (2008), Reflecting Environmental Land Use Needs into EU Policy: Preserving and Enhancing the Environmental Benefits of Unfarmed Features on EU Farmland, Final Report for DG Environment, IEEP, London.

Freibauer, A., Rounsevell, M.D.A., Smith, P., Verhagend, J. (2004), Carbon sequestration in the agricultural soils of Europe, Geoderma, 122.

Fuglie, K. O., Kascak., C.A. (2001), Adoption and Diffusion of Natural-Resource-Conserving Agricultural Technology, Review of Agricultural Economics 23 (2).

INEA (2009), Annuario dell'agricoltura Italiana, Volume LXII, 2008, Edizioni Scientifiche Italiane, Napoli.

Nalukenge, I., Antle, J.M., Stoorvogel, J. (2009), Assessing the Feasibility of Wetlands Conservation: Using Payments for Ecosystem Services in Pallisa, Uganda. In: Lipper L. *et al*. (eds.), Payment for Environmental Services in Agricultural Landscapes, Natural Resource Management and Policy, 239.

Paustian, K., Antle, J., Sheehan, J., Paul, E. (2006), Agriculture's Role in Greenhouse Gas Mitigation, Pew Center on Global Climate Change, Arlington.

Povellato, A. (2010), "Floor and Trade": un nuovo meccanismo per incentivare la sostenibilità in agricoltura?, Agriregionieuropa 6 (21).

RISE (2009), Public goods from private land, Rural Investment Support for Europe Foundation, Brussels.

Soussana, J. F., Loiseau, P., Vuichard, N., Ceschia, E., Balesdent, J., Chevallier, T., Arrouays, D. (2004), Carbon cycling and sequestration opportunities in temperate grasslands, Soil Use and Management, 20 (2).

Stern N. (2007), The Economics of Climate Change: The Stern Review, CUP, Cambridge.

Stoorvogel, J.J., Temme, A.J., Antle, J.M., Claessens, L. Schoorl, J.M. (2009), A novel site-specific methodology to assess the supply curve of environmental services, Proceedings of the Conference on Integrated Assessment of Agriculture and sustainable Development; Setting the Agenda for Science and Policy (AgSAP 2009), Egmond aan Zee, The Netherlands, 10–12 March, Wageningen.

Sunding, D., Zilberman, D. (2001), The Agricultural Innovation Process: Research and Technology Adoption in a Changing Agricultural Sector. In: Gardner, B.L., Rausser, G.C. (eds.), Handbook of Agricultural Economics, Elsevier, Amsterdam.

TEEB (2009) The Economics of Ecosystems and Biodiversity for national and international Policy Makers, United Nations Environment Programme.

Tietenberg, T. (2010). "Cap-and-Trade: The Evolution of an Economic Idea." Agricultural and Resource Economics Review 39 (3).

Vleeshouwers, L.M., Verhagen, A. (2002), Carbon emission and sequestration by agricultural land use: a model study for Europe, Global Change Biology 8.

Wissel, S., Watzold, F. (2010), A Conceptual Analysis of the Application of Tradable Permits to Biodiversity Conservation, Conservation Biology, 24 (2).

Zhang, W., Ricketts, T.H., Kremen, C., Carney K., Swinton, S.M. (2007), Ecosystem services and dis-services to agriculture, Ecological Economics, 64 (2).