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PAYMENT FOR ECOSYSTEM SERVICE FOR CARBON CREDITS FROM ITALIAN OLIVE GROVES. SOME ISSUES REGARDING THE MODE OF PAYMENT

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Abstract

In Italy, olive farming is one of the most interesting examples of carbon sink in agricultural soils. The olive agro-ecosystems can in fact ensure effective action in CO_2 fixation encouraging the process of carbon storage on the organic matter of the soil. Starting from the assumption that a different and more "carbon oriented" management of Italian olive groves system could represent a promising way to increase the carbon stored in agricultural land, this paper explores the possibility to implement a Payment for Ecosystem Services (PES) scheme to increase the provision of carbon sink by olive groves. The analysis focuses on the definition of the sealable ecosystem service, according to the actual policy framework and on the mode of payment that could be established. Results, suggest that an output-based payment, though more environmentally efficient, could not be enough to incentivise farmers to join the PES, as the payment per hectare might be lower using this approach.

Keywords: *Payment for Ecosystem Services, soil carbon sink, mode of payment, FADN*

1. Introduction

Climate stability is an example of a pure public good, as the outcome of the efforts to tackle global warming is completely non-rival and non-excludable. Like many other pure public goods, thus, climate stability is underprovided by all economic sectors (Hardin, 1968). Despite on global scale energy production is one of the major drivers of climate change, agriculture has a central role in delivering climate stability. According to some relevant studies on this topic (Smith *et al*., 1997 and 2007), agricultural and forestry soils and biomasses, as a natural sink for carbon (C), have a central role in climate change mitigation agenda, with 90 per cent of total agricultural greenhouse gases emissions (GHG) mitigation potential attributed to agricultural soils worldwide. However, the delivery of climate stability through agricultural practices is a typical example of under-provision of a public good, especially when carbon dioxide (CO_2) fixation is the only benefit and it doesn't come with other private co-benefits (like soil fertility, productivity growth, etc.). In other words, there is no incentive to fight global warming, as the benefits are not local, but global by definition (OECD, 1998).

In Italy, in particular the olive cropping system is a very important example of carbon sink in agricultural soils. These agro-ecosystems are characterized by the high level of ecological complexity unlike many other cropping systems; olive trees have a great ability to adapt to different environmental conditions with a very long crop cycle (over 50 years). This ensures effective action in CO_2 fixation encouraging the process of carbon storage on the organic matter of the soil.

Starting from the assumption that a different and more "carbon oriented" management of Italian olive groves system could represent a promising way to increase the carbon stored in agricultural soils, this paper explores the possibility to implement a Payments for Ecosystem Services (PES) scheme to increase the provision of carbon sink by olive groves.

PES represent a mechanism through which subjects that are the beneficiaries of a certain ecosystem service individuals (i.e. communities, businesses or government-acting on behalf of public interest), provide payments for management actions that are likely to increase the provision of the service itself. The idea behind PES is that those who provide ecosystem services – like any service – should be paid for doing so. The basic concept of PES derives from its focus on the 'beneficiary pays principle', instead of the 'polluter pays principle' (Engel *et al*., 2008). Thus, PES provides an opportunity to set a price on un-priced ecosystem services-like climate regulation, seeking to internalize what would otherwise be an externality (Pagiola & Platais, 2007). In other words, the PES are incentive or market based mechanism to translate external, non-market values of the environment into real financial incentives for local actors to provide such services (Engel *et al*., 2008).

Literature on Payment for Ecosystem Service (PES) has become extensive since this kind of mechanism has attracted increasing interest over the past decades (see among others: Pagiola, 2005; Engels, 2007; Dobbs and Pretty, 2008). According to the OECD (2010), there were already more than 300 PES or PES-like programmes in place around the world by 2010 at national, regional and local levels.

For the purposes of this study, we will refer to an extensively quoted definition of PES by Wunder (2005), that has been used in seminal works on this topic (see among others: Engel *et al*., 2008; Smith *et al*., 2013). This definition identifies a PES as "a voluntary transaction where a well-defined ecosystem service (or a land-use likely to secure that service) is 'bought' by a (minimum of one) ecosystem service buyer from a (minimum of one) ecosystem service provider; if and only if the ecosystem service provider secures ecosystem service provision (conditionality)" (Wunder, 2005).

From an economic point of view, PES programs try to put into practice the Coase theorem, according to which the problems of external effects can, under certain conditions, be overcome through private negotiation between affected parties (Coase, 1960). However, the Coase theorem has very different implications when transaction costs are zero, in which case, the property rights are very important. Indeed, not all environmental problems can be addressed via a PES scheme, thus the issues of land ownership and property rights are central. In fact, ecosystem managers may not have the authority to manage environment, because the ecosystems belong to nobody or to the state and therefore are incline to disregard even the on-site impacts of their management decisions (Ostrom, 2003). It is thus important, for the realization of a PES scheme, when transaction costs are zero, that managers have appropriate property rights. In the case study analysed, however, this issue shouldn't be relevant, as farmers have property rights for changing management practice, even if not land use.

This aim of this work is to analyse two important elements of the construction of the PES scheme, according to a recent study (Smith *et al*., 2013): the identification of a saleable ecosystem service and the definition of the mode of payment. These two elements are strictly interrelated in the case here analysed, as the policy framework defines the amount of carbon credits that can be sold (see section 2.1) and, thus, the level of output based payment that buyers would be willing to pay.

To conduct this analysis, in section 2, will be investigated two main aspects that concern the identification of a saleable ecosystem service: the actual policy framework and the cause-effect relationship. In section 3 will be described the geographic area to which the methodology has been applied. Section 4, will analyse the payment scheme and in section 5 the issues regarding the definition of the price and the mode of payment will be analysed more in detail. In fact, the payment should be structured in a way that it can grant the incentive to the sellers to provide that good and to the buyers to compete with the cost of alternative means of securing the desired service (i.e. the price of 1 ton of CO_2 in alternative markets). To this extent an output-based payment (i.e. a payment based on the ecosystem service provided) is estimated as the price of the tons of CO_2 sequestered in soils, then, this payment it is compared to the cost for the farmers to implement some practices that can increase soil C (i.e. an input-based payment). Estimation of these costs are provided using FADN (Farm Accountancy Data Network) sample for Italian farms, data collected from Rural Development Programmes (RDPs) and from analysis of the Italian olive oil sector. Finally, section 6 summarises the key elements emerged and proposes some concluding remarks.

2. Identifying a Saleable Ecosystem Service

The first phase when defining a PES scheme is the identification of a saleable Ecosystem Service (ES).

An important distinction, within the ES to which PES might be applied, can be made on the basis of whether the ES provided are public goods or not, as this has implications for how PES can be implemented. In fact, it is often supposed to be implicit that all ES have the characteristics of non-excludability and non-rivalry in consumption of the pure public goods (i.e. users cannot be prevented from benefiting from the ES provided and the consumption by one user does not affect consumption by another). However, this is not always true and the existence of this condition could change some PES development conditions (e.g. clear definitions of the actors involved; problems of free riding, etc) (Engel *et al*., 2008). This circumstance certainly holds in the case analysed, as climate stability, which is the consequence of C sequestration practices incentivised by the PES scheme, is an example of pure public good. In fact, citizens cannot be prevented from benefiting from the ES provided and their "consumption" of climate stability does not affect consumption by others.

Once that the nature of the public good to sell is determined, other two main aspects deserve attention in identifying a saleable ES, in the case analysed; these are: the policy contest that frames the ES and the cause-and-effect relationship that can provide the ES itself.

2.1. The Policy Contest

Soils contain twice as much carbon as in the atmosphere in the 0-30 cm layer alone (IPCC, 2006). Thus, the removal of CO_2 from the atmosphere through management practices that enhance soil C sink, could be a promising way to tackle climate change on a global scale. However, like any other public good, it could be subjected to under-provision (Hardin,

1968) for the maximisation of private utility. In fact, intensive cultivation has reduced in the long run, the stocks of soil organic carbon in European soils (Freibauer *et al*., 2004).

To hamper this under-provision, some European and national policies do already contemplate options for maintaining and restoring soil carbon. Looking at the Common Agricultural Policy (CAP), in particular, cross-compliance conditions in the first Pillar and voluntary agri-environment-climate measures in the second Pillar, are aimed at maintaining or increasing level of soil organic carbon in agricultural soils. Even in the regulation for programming period 2014-2020 of the Rural Development Policy, climate change mitigation has assumed a central role and, particularly in the Priority 5 has a specific focus area, promoting carbon sequestration and sink in the agricultural and forestry sector (Council of the European Union, 2013a).

In addition, in the new regulation of the CAP also the green payment introduce to the first pillar, has the scope to promote climate stability, by linking farmers eligibility to this new payment to the compliance to three (or to equivalent) practices, that are supposed to be beneficial for the environment and climate. The three measures are crop diversification, maintaining the share of permanent grassland and maintaining ecological focus areas on their land (Council of the European Union, 2013b).

Besides CAP, from a regulatory point of view, national soils legislation may provide some legal protection in some countries, but not uniformly at European level. On this field a plan of a European regulation to require land managers to maintain existing soil carbon (or a minimum level of soil carbon), was contained in the proposal for a Soil Framework Directive in 2006, which was prevented from advancing in the Council, leaving Europe without a regulatory framework for soil protection.

Meanwhile, in the framework of the European climate policy, the importance of land use management on carbon stocks has been recognised with the decision n.529/2013/UE to establish a framework to harmonize accounting rules for greenhouse gases emissions and removals at European level from Land use, land use change and forestry (LULUCF) sector. Within this news framework, from 2021, Member States should account also for GHG fluxes from grassland and cropland management that are not accounted for in the Kyoto Protocol monitoring system. By now, the declared objective of this European Decision is just to account for these emissions, but this framework could pave the way, once that measures have proven to be robust, for an inclusion of soil carbon changes towards EU targets under climate change policy.

Nevertheless, incentives under the LULUCF accounting framework are not expected in the medium term and the CAP remains the only way to implement measures that can maintain or enhance carbon stocks in soils and biomass. From this point of view, even if there are some positive elements emerging from the past (i.e. agri-environment) and some expectations for the future (i.e. greening and agri-climate-environment measures) it doesn’t seem that the CAP measures could make much a difference (Matthews, 2014).

Thus, while waiting for a regulation at European level, an interesting approach to explore could be a voluntary PES-like programme to carbon sequestration in soils. This kind of approach could also represent a frontrunner to allow emission reductions in the LULUCF sectors as offsets in the European Emissions Trading System (ETS). In fact, as LULUCF is not included in the EU climate policy (till now), it could be linked to the ETS permitting agricultural and forestry soil carbon offsets to count for compliance with emissions target (Matthews, 2014).

Other possibilities to valorise this kind of environmental commitment of farmers, could be to directly use carbon credits to compensate agricultural production GHG emissions or to sell agricultural products with a carbon footprint label (indicating the lower emissions of the product, or the company's commitment to reduce GHG emissions).[1]

The analysis of the policy framework, is important to understand which policy measures, instead of PES, could ensure the provision of soil C sinks and to exclude the possibility to incur in the so-called double-counting, i.e. when two (or more) buyers claim ownership of specific emission reductions or carbon offsets.

The possibility to incur in double-counting, in particular, determines that the only C credits that can be sold are those generated by the increases in soil C resulting from alternative management practices. In fact, even if olive groves ecosystem has a high capacity of C storage (see section 2.2), also (and maybe mostly) in trees biomass, these sinks are already accounted for by the National Inventory Report of emissions carried out form the Institute for Environmental Protection and Research (ISPRA) to comply with the monitoring system of the EU and the Kyoto Protocol (ISPRA, 2014). Thus, they were not considered as possible credits to sell by farmers.

However, looking at the near future, the same problem of double-counting could potentially occur with the carbon stored in soils, when will come into force the monitoring of emissions and removals in accordance with the decision on LULUCF accounting (529/2013/UE). When this framework will apply, hence, there will be the need to evaluate if a problem of double-counting arises and how to possibly overcome it.

2.2. Cause-and-Effect Relationship

Verifying the existence of a cause-effect relationship between land or resource management interventions and the provision of ES, is fundamental to give assurance to buyers about the possibility that they will receive the required benefits. This implies that the PES system is based on a strong scientific basis in order to attract more buyers.

This point is probably one of the biggest obstacles in standardizing an approach to a PES scheme to enhance sinks in soil organic carbon, as the amount of C cannot be efficiently measured, but must be estimated and the estimation methodologies may lead to incorrect quantifications. Moreover, soil C dynamics are complex and the relationship between management actions and the provision of C sink in soil is not "direct" and can be influenced by external factors (World Bank, 2011). For this and other reasons it has been choose to elect only some practices whose impact in soil C was not controversial.

In this case study the reference cropping system is the olive grove. This is characterized by the high level of ecological complexity and the remarkable ability to adapt to different environmental conditions (Facini *et al.*, 2007; Palese *et al.*, 2013, Nardino *et al.*, 2013). In this context, the use of specific cropping patterns according to the concept of good agricultural practices, such as cover crop between rows, ground cover of herbaceous plants and use of pruning as soil improvers, may slow the release of carbon dioxide resulting from natural respiratory activity of the soil, encouraging the processes of storage of Soil Organic Carbon (SOC). Overly intensive management practices, conversely, could facilitate the degradation of organic carbon resulting in substantial losses, and increasing the emission of CO_2 from the soil (Castro *et al.*, 2008; Marquez -Garcia *et al.*, 2013).

The specific public good analysed, creates further problems related to the technical issues of additionality and permanence of the ES provided, that are always central in the definition

[1] These latter kinds of initiatives that look at the consumption, rather than at the productions stage, are becoming more and more important, and in Europe there are institutional initiatives to standardise the approach to the calculation of product carbon footprint for food. (see: http://ec.europa.eu/environment/eussd/smgp/product_footprint.htm)

of a PES scheme. These elements are not the focus of our analysis and thus they will not be described in detail, but still some assumption that have been made for the purposes of this work, deserve some attention.

Additionality occurs when payments are made for actions over-and-above those which land managers would generally be expected to undertake, i.e. beyond regulatory compliance (Smith *et al*., 2013). The lack of additionality is known as the issue of “money for nothing” (Ferraro & Pattanayak, 2006), that is paying for adoption of practices that would have been adopted anyway. Additionality, thus, represents a potential problem of financial efficiency for the program, which is generating less ES per dollar spent. It could also result in social inefficiency when funds for PES are limited, reducing money available to induce socially-efficient management practices elsewhere (Engel *et al*., 2008).

The issue of additionality could be addressed involving farmers and other stakeholder in the definition of the practices, defining long term trend in land use changes and technical management practices, lessening the eventual opportunistic behaviour of farmers.

The risk of permanence, is a very important issue that characterizes all the projects that deal with carbon sinks from land use activities and is one the obstacles to the inclusion of agricultural C credits in off-set crediting mechanisms e.g. CDM-Clean Development Mechanism in the United Nations Framework Convention on Climate Change (World Bank, 2011). The central issue is whether there is a risk of potential reversibility of the carbon stored, as a result of biotic or abiotic disturbances.

Critics of PES in the agricultural sector have underlined that permanence may be caught up by changes in external conditions (e.g., increases in market prices that change opportunity costs of competitive land use) or by lack of long-run funding for PES (e.g., due to limited project durations) (e.g., Swart, 2003).

In order to decrease this kind of risk, the scheme should include safeguards to ensure the permanence of the interventions like developing strategies to mitigate the identified risks. Maybe the selling of a lower amount of credits than the total provided (applying a buffer discount), is the easiest way to account for unforeseen circumstances that might compromise delivery. The UNFCCC, for example, overcomes the problem considering afforestation and reforestation as projects that provide a temporary solution to climate change mitigation. Thus they can generate temporary carbon credits that in time need to be replaced with permanent credits (UNFCCC, 2006).

Pagiola and Platais (2007) propose a similar viewpoint on the issue of permanence. They state that, as one of the advantage of PES is exactly that it should be able to adapt to changing conditions, it gives the possibility to re-negotiate the contracts and, as long as participation is voluntary for both parties, both have the option to walk away at any point if conditions change. Besides, as the basic logic of PES is of compensating ES providers for the externalities they generate, this means that in theory, ‘after payments end’-there cannot be any expectation of permanence.

3. Identifying the Geographic Area

Once that the sealable ES has been identified, some technical issues need to be solved, among these, for the purposes of this study, we have focused only on identifying the geographic area on which to apply the scheme and defining the mode and the level of the payment (section 4 and 5).

Identifying the geographic area on which to apply the scheme and check for potential hot spot areas, which can provide high benefits in relation to multiple ecosystem services, is the first step that should be analysed. Generally, ecosystem service benefits are not spread uniformly across geographic areas: there are in fact some areas that may be considered 'hotspots' in terms of ecosystem service benefits, i.e. that provide highly valued benefits in relation to multiple services (Smith *et al*., 2013). In this study the geographic area selected is Veneto Region on which there were some previous works (Coderoni *et al*., 2013; Coderoni *et al.*, 2014) that provided data to further elaborate. Despite the area perhaps is not the most adapt, as olive groves in Veneto Region are not the prevalent cropping system, high quality olive oil production trees are yet present in the provinces of Verona, Vicenza, Treviso and Padua. Besides, what is of interest is not the area covered itself, but the feasibility of the scheme, to eventually implement on a more proper area and spatial scale.

In fact, PES schemes can be developed at a range of spatial scales, including: international, national, catchment or local/neighbourhood (Smith *et al*., 2013). For the nature of pure public good of climate stability, the international spatial scale could be the proper one. In fact, the general assumption, when dealing with carbon credits, is that a ton of CO_2 removed from the atmosphere as the same value all over the world, as climate change is determined by global concentration of GHGs. The UNFCCC Reducing Emissions from Deforestation and Degradation (REDD+) programmes are a typical example of international scheme as developed countries pay developing countries to reduce emission from forests.

Still, despite the nature of the public good analysed, the interest of local communities to a "local" carbon credit, which usually generates more trust on its verifiability, could generate the demand for ES also at local level.

Choosing to arrange a PES in a confined area has the advantage of more easily identify targeted actions (Muradian *et al*., 2010) to ensure the provision of the service and, at the same time, to make the PES most adaptable and flexibly to local needs. On the opposite side, one risk that could be experienced in implementing the scheme in geographically limited areas, is the lack of availability of sufficient sellers, which makes it difficult the implementation of the PES.

In the case of Italian olive groves system, it could be preferred to take a regional or local approach, to better capture the different geographical condition and farming practices, or, when establishing a national system, it would be better to differentiate payments in order to target sellers with lower opportunity costs for alternative land use (OECD, 2010).

An issue that deserve some consideration is how representative could be data so site specific for Italian or European situation. As already mentioned, the decision to focus the study on olive grove derives mainly from the biophysical efficiency in the carbon soil storage of this cropping system. In addition, the olive groves are a widespread cultural practice in the Mediterranean latitudes, therefore, representative of the Italian agriculture. However, in the specific case of Veneto, the olive is a crop relegated only to a few ecosystems characteristic of areas such Lake of Garda and the Euganei Hills. Thus, in general this study is more useful to explore the potential of the FADN database for the analysis proposed, rather than to give exact values to upscale at European or Italian level. Nevertheless, as much of the communication of GHG data to the Kyoto Protocol and the European monitoring system, or under the LULUCF accounting framework, rely on Tier 1 approach (i.e. data with high degree of uncertainty), this results, could represent a quite good basis to be generalised with the same level of uncertainty.

4. The Payment

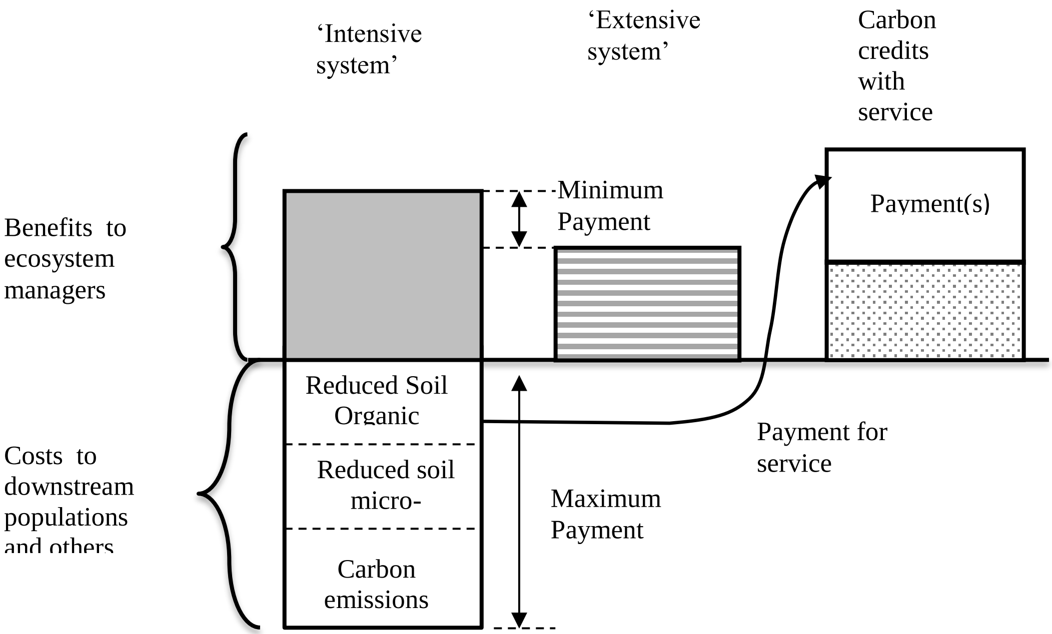
An essential element in the initial structuring of a PES scheme is the analysis of the costs necessary for system development and thus the definition of how the scheme will be financed.

The costs are divided generally into short-term design and capacity building costs, and long term costs: the former are composed by the costs for the design and structuring of the PES; while the long-term implementation costs cover the payments necessary to generate and provide the ES provision (Smith *et al.*, 2013). The design and capacity building stage may necessitate a quite large financing for funding for research (to create metrics for the ES), stakeholder engagement, contract preparation and data collection. The longer-term implementation costs, instead, include the actual payments for ES as well as the costs of maintaining the scheme itself (e.g. the costs of monitoring, evaluation and review). All transaction costs associated with PES schemes can be in theory large and they are generally directly linked to the number of actors (Engel *et al.*, 2008). Quite small PES scheme can help reducing them.

For the purposes of this work that are mainly related to farmers' willingness to provide carbon sequestration in soils, we wanted to focus on the price to be given to the farmers to persuade them to join the scheme. The other costs of the PES programme will be disregarded.

Indeed, a central issue, in PES scheme design is to understand if subsidies affect optimal choices. An extensive literature has addressed this issue (see among others: Capitanio *et al.*, 2014; Marangon and Troiano, 2013; Benton, 2012). For the scope of this work, we will hypnotise that if the subsidy is higher than an estimated level, it will influence optimal choices.

The payment offered to ecosystem managers should generally range between a minimum and a maximum level (Figure 1). When considering a PES which implies a change in farm management to provide a greater ES benefits, the minimum payment should at least cover any (private) net return forgone by the farmer, as a result of reduced agricultural production. The theoretical maximum payment should represent the cumulative value of additional ecosystem service benefits which would add to the buyer(s) (Engel *et al.*, 2008).



Source: Adapted from Pagiola and Platais (2007).

Figure 1. The logic of payments for ecosystem services.

As these benefits are not easy to quantify, and might be generate by the same type of management techniques, usually PES payments are agreed as an intermediate point between the minimum and maximum values, reflecting supply and demand for particular ecosystem services (Smith *et al*., 2013). Many PES programs use fixed payments per hectare for given activities; however, a more efficient payment structure should differentiate the ES price according to different space, and/or sellers, on the basis of the ES provided (benefit targeting), the costs of ES provision (cost targeting), or a mixture of both (Engel *et al*., 2008).

In particular, for what concerns the cost targeting, a promising way to make PES more cost-effective is to differentiate and prioritise payments to those spots where farmers have lower opportunity costs for alternative land use (OECD, 2010). Of course obtaining information about the farmers opportunity cost is not an easy task, as they could have the incentive to overstate the costs they effort, in order to fix a higher price. Thus, information on the sellers costs should be based on costly-to-fake signals (OECD, 2010), like distance to markets, soil fertility or type, prices of production input, labour, productivity, etc., that should be used to estimate the opportunity cost.

Looking at the PES for the olive sector, the main long term implementation costs are linked to the introduction and maintenance of management techniques to sustain the carbon sinks (especially the cultivation operations related to grassing or residue management), as well as the cost of skilled labour (e.g. pruning).

To give a roughly estimation of the payment that would incentivise farmers to join the PES, we have valued the cost of introducing the management practices suggested to increase soil C with two different approaches, trying, in both cases, to link the payment estimation to costly-to-fake signals.

From one side it has been used a “costs estimation approach” summing all the increasing in costs of production derived from the implementation of the proposed practices, moving from the assumption that, at best, if they don’t affect productivity, the introduction of these practices in the farm would not change the level of revenues. This costs are production costs, concerning intermediate operations (tillage, fertilizers, pesticides, labour costs, etc..) and services (rental, water and energy, insurances, transaction costs and other expenses), obtained both from review of supplementary documents for the definition of agri-environment payments in RDPs of different Italian regions and on data collected from the Italian olive oil sector (ISMEA, 2012). These results (table 1) show a minor unitary gross margin of 165 €/ha in the case of the practices proposed by the Agri-environmental scheme.

From the other side, it has been used a “gross margin approach” starting from the assumption that a change in practices could bring also a change in gross margins. An opportunity cost of changing olive system input intensity has been estimated, using micro economic data from Farm Accountancy Data Network (FADN).

In this second approach, the distinction between intensive and conservative olive groves has been made taking into account the context indicator number 33 “Farming intensity”, proposed by the European Commission for the definition of the 2014-2020 RDP[2]. More precisely for each of the 15 farms of the sample it was calculated the sub-indicator “Farm input intensity” distinguishing from farms with low, medium and high input level, defined on the basis of input expenditure according to the guidelines for the calculation of the agri-environmental indicator 15 of IRENA project[3].

[2]http://ec.europa.eu/agriculture/cap-post-2013/monitoring-evaluation/documents/proposed-list-common-context-indicators_en.pdf (last access on May 2014).
[3]http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Agri-environmental_indicators (last access on May 2014).

The opportunity cost of switching from intensive to extensive system, was then approximated with the difference between the average unitary gross margins of the olive farming systems of farms with different input intensity index (Table 1) and has been calculated only for farms with more than one hectare of UUA cultivated with olive groves. The mean value obtained (-537 €/ha) represents the opportunity cost of changing olive grove system from high to low-medium input intensity.

Table 1. Average Unitary Gross Margin and Unitary Opportunity Costs for Each Management Type and Reference Source

Source elaboration	Management type	Average unitary gross margin (euro/ha)	Unitary opportunity cost (euro/ha)
Gross margin (FADN)	Low Farm input	1,417	
	Medium-High Farm	1,953	-537
Costs estimation	Agri-environmental	420	
	Baseline	585	-165

Source: Own elaboration

5. Mode of Payment

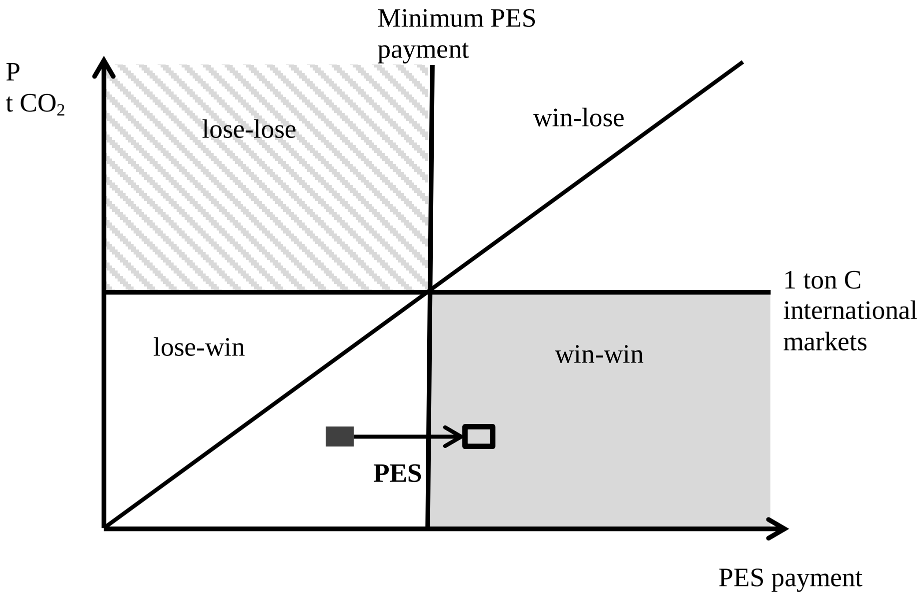
This phase is closely related to the previous one, with regard to the cost definition. Designing the mode of payment is an essential element for the functioning of a PES scheme. The basic choice to make is to decide whether the buyers will compensate the sellers with an output or an input-based payment. An output-based payment is usually based on the level of ecosystem service provided, i.e. each ton of carbon provided; the input-based payment is estimated through the costs of introducing management actions likely to sequester soil carbon (above the baseline). Due to the difficulty of measuring the level of service provided, an input-based payment is more commonly used. This happens for many reasons, very relevant when analysing a PES on carbon credits, that are: the importance of the monitoring costs, the potential influence of natural disturbances on supply (that might affected, besides changes in land management, the output of the ecosystem service) and the difficulties in ascribing eventual provision changes to individual sellers (Muradian *et al*., 2010).

However, the importance of input-based payments in PES schemes, contrasts with the increasing emphasis on 'payments by results' that increase efficiency and innovation. In fact as underlined by many scholars (Jack *et al*., 2008), the incentive to innovate may be weakened by payment based on proxies, as farmers are not encouraged to innovate to reach the same result, but only to follow a specific protocol.

In the case of the PES analysed, the choice is whether to pay for an additional ton of carbon sequestered or for carbon oriented management practices of olive trees.

The first step to analyse when carrying out this analysis, is to recognize that, like every other market, different modes and levels of payment, can generate different level of expected welfare (benefits) for the actors involved, those affecting their decision to join or not the PES scheme.

Figure 2 summarises the different options that can rise in the market. The figure is based on Pagiola *et al*., (2005) framework to analyze the effectiveness of PES programs, but is here readapted to plot the hypothetical price of a ton of CO_2 (vertical axis) and PES payments (horizontal axis), in order to understand whether and if there can be market opportunities for soil C credits. The basic assumption is that buyers will be willing to purchase a soil C credit if the price is beyond the average price of tons of CO_2 in alternative (international or not) markets. On the other hand, farmers will be convinced to participate if the PES premium covers at least the minimum PES level payment (see Figure 1). Thus, in this figure: bottom-right rectangle is 'win-win' as the price is acceptable for farmers and cheaper of other carbon credits for the buyers. At the opposite side, top-left rectangle is 'lose–lose' (too high price for buyers and too low for sellers). The diagonal separates practices whose desirability to society is positive (below), from those where it is negative (above). In the bottom-left and top-right rectangles there is room for intervention. At top-right, famers would partecipate, but buyers would face higher prices; at bottom-left, practices are unprofitable to land users but buyers would partecipate to the PES scheme. In this last chance, the goal of PES programs is to make profitable to individual land users to join the scheme. To this extent could be particularly useful PES programs aimed at encouraging agricultural sector (or particular productions) to enhance the provision of soil C credits.



Source: Based on Pagiola *et al.*, 2005.

Figure 2. Benefits for Buyers (Collectivness) And Sellers (Farmers) in a PES Scheme for Soil C Sinks

To assess what would be the ideal price paid by the PES buyers, a potential output-based payment based on the tons of carbon sequestered, has been evaluated using a simplified methodology to estimate the quantity of carbon stored with the alternative management of the olive grove (section 5.1). Then, the amount of C has been multiplied for the current market price of the alternative carbon credits deriving from voluntary carbon markets in Italy (INEA, 2014). The value obtained has been compared to the range of input-based payment, calculated in the previous section.

One of the major challenges to assess the amount of C stored in olive groves, was the availability of reliable and extensive data, needed to calculate the change in carbon stocks in the soil and, therefore, to verify the increase in carbon sink. In this study the approach followed is taken from IPCC methodology for the LULUCF, adapted at farm level using the FADN based methodology illustrated in previous works (Coderoni *et al*., 2013 and 2014;

Coderoni & Bonati, 2013). The aim of this simplified methodology was to have a first estimation of the ecosystem service provided, identified in the annual change in carbon stocks in soils associated with different management models of olive grove. More precisely the change of soil organic carbon has been calculated assuming the conversion from intensive olive grove ("intensive" scenario) to olive trees under cultivation practices in low-intensity use of inputs ("conservative" scenario) on a time horizon of 20 years, in order to highlight the performance of production in relation to the storage of carbon. The analysis was conducted with reference to the olive farms in the Italian region of Veneto using FADN database in the year 2011.

The fraction of organic C in soil is determined by the product of the baseline C stock (ton/ha) and specific stocks variation factors, as follows:

$$SOC = \sum_{c,s,i} SOC_{REFc,s,i} \cdot F_{LUc,s,i} \cdot F_{MGc,s,i} \cdot F_{Ic,s,i} \cdot A_{c,s,i} \qquad (1)$$

Where *c*, is the specific climate zone; *s*, the type of soil and *i*, the set of land use systems in the geographical area (e.g. region, country, etc.). The coefficient F_{LU} is factor of variation of C according to the land use system of; F_{MG} is the factor of variation on the system management; F_I is the factor of variation of inputs of organic matter applied to soil (e.g., organic fertilizer); A is area analysed with the homogenous biophysical conditions (same climatic conditions) and management history. The reference stock (SOC_{REF}) is the estimated value under native vegetation in the first 30 cm of the profile. These values are classified by IPCC on the basis of global climatic regions, according to the type of soil soils. Starting from reference values and related factors, one can estimate the average annual change in the stock of organic C according to the type of soil and climate, the farming system and management practices. These data are reported, for each case study, in the IPCC guidelines (2006).

In the specific case study were selected data from 15 olive farms from FADN sample of Veneto region (708 farms), that represent 466.55 ha of UAA and 18.38 ha of olive UAA. For each farm has been recognized the territorial location (company code, geographical coordinates, utilized agricultural area - UUA), costs of production (fertilizers, pesticides, energy consumption, etc.) and type of productions.

The data relating to soil and climate were derived from the soil map of Veneto (ARPAV, 2005), based on the geographical coordinates of the farm location, while the climate zone has been classified in accordance with the IPCC Guidelines (2006). With these parameters it is possible to apply the IPCC methodology for the LULUCF sector, in order to quantify the baseline C stock (ton/ha), identifying the coefficients of the factors listed in the equation (1). The baseline C stock was determined in three contexts: i) the baseline scenario in which for each farm were applied to the coefficients configured according to the actual management model (SOC_{bas}); ii) the intensive scenario in which the lands with olive trees are managed with the intensive model (SOC_{int}); iii) the conservative scenario, for which the coefficients are weighted on the low- range input (SOC_{cons}). The discrimination between intensive and conservative olive groves has been made using the same indicator used for the opportunity cost assessment (see section 4).

The results obtained show a provision of an ecosystem service of about 1,895 tons of annual carbon storage in the soil in the baseline scenario (table 2). Considering the intensive scenario the SOC is equal to 1,547 tons per year, and in the conservative scenario to 2,678 tons per year. Hence in case of switching from intensive to conservative management the annual variation of SOC (ΔSOC) is about 3 tons per hectare per year, which means that for every ton of carbon is necessary to convert about 0.32 hectares of intensive to conservative olive grove. In terms of carbon dioxide (CO_2), using the IPCC (2001) conversion factor $C/CO_2 = 1/3.67$, for every ton of CO_2 stored in the soil is necessary approximately to convert about 0.1 hectares.

Table2. Distribution of UAA, SOC and Average Annual Variation of SOC in the Switch from Intensive Scenario to Conservative Scenario on the Sample of 15 Farms

Farm	SOC_{bas} (ton/year)	SOC_{cons}(ton/year)	SOC_{int}(ton/year)	$\Delta SOC_{cons\text{-}int}$(ton/year)	Unitary $\Delta SOC_{cons\text{-}int}$(ton/ha·year)
1	176.82	306.03	176.82	6.46	3.08
2	18.52	32.06	18.52	0.68	3.09
3	86.1	119.5	69.04	2.52	3.07
4	5.05	8.74	5.05	0.18	3.00
5	118.66	164.67	95.14	3.48	3.08
6	16.84	29.15	16.84	0.62	3.10
7	77.24	77.24	44.63	1.63	3.08
8	33.68	58.29	33.68	1.23	3.08
9	176.82	306.03	176.82	6.46	3.08
10	63.99	110.75	63.99	2.34	3.08
11	139.77	241.91	139.77	5.11	3.08
12	12.63	21.86	12.63	0.46	3.07
13	598.53	830.65	479.93	17.54	3.08
14	1.68	2.91	1.68	0.06	3.00
15	368.69	368.69	213.02	7.78	3.08
Total	1,895.03	2,678.48	1,547.57	56.55	3.08

Source: Own elaboration on FADN data

Once obtained this average value of carbon credits generated within the PES scheme, the price of one ton of CO_2 has been assumed to be equal to the mean value of credits exchanged in Italian voluntary carbon market. Data of C credits in the voluntary market in 2011 - are provided by the INEA (2014) and were collected through online surveys with the main actors in the voluntary market for national carbon credits. According to these data, the volume of C voluntary trade in Italy, in 2011, involved 244,181 tons of CO_2 for a total value of trade up to 2 million euros. The price of each ton of CO_2 fixed, ranged from 1 up to 58 €/tCO_2, with an average of 5.34 €/tCO_2. This average value of C credits exchanged in the Italian voluntary carbon market has been multiplied by the average tons of C that are supposed to be stored (according to our estimation) in one hectare of olive grove extensively managed soil. The theoretical output-based payment estimates, ranges from 11 to 655 €/ha, with an average value of 60€/ha.

Generally speaking, if there aren't particular incentives or specific interest in supporting local olive groves agro-ecosystems, an output-base payment can attract buyers if and only if, it is at least equal to the price of alternative carbon credits. Moving from this assumption, the output-based payment, which results from our estimation, does not represent an incentive for farmers if compared to input-based one. In fact, on one side there is a situation for which sellers are incentivised to join the scheme for a price ranging from 165 to 537€/ha of payment, while buyers are willing to pay from 11 to 655 €/ha. In other words, buyers should pay the higher price for ton of CO_2 sequestered in soils, in order to compensate the farmers' management practices (moving from bottom-left rectangle in figure 2, to bottom-right). Moreover, when considering the buffer discount of ES provided with the PES, the C credits sold diminish, thus lowering the payment that farmers can receive.

6. Conclusions

Sequester soil carbon through agricultural practices, could be a promising way to ensure sector contribution to the European climate policy goals. Yet, since climate stability is an example of a pure public good, it is often underprovided and there is need for policy intervention to ensure its delivery. European policy agenda to guarantee soil carbon sequestration embraces several measures ranging from incentives (like agri-environment) and compliance tools (e.g. the green payment of the CAP), while a regulatory approach is still far from being implemented. All these approaches show some limitations and thus it could be interesting to analyse newest way to incentivise practices that could provide higher level of soil C sequestration.

One of this promising ways could be the establishment of a PES scheme from olive groves C credits. In fact, PES scheme could represent a frontrunner for agricultural carbon compliance off-setts markets, by developing capacity building in the implementation of such a scheme and in the establishment of protocols for the metrics of soil carbon changes, in order to favour the development of approaches that could benefit both the agricultural and ETS sectors; the former with a differentiation of income and the latter with the possibility to offset emission in a likely cheapest way.

The aim of this initial contribution on that issue was to analyse two main elements when defining a PES scheme: the identification of a saleable ES and of the mode and level of payment. In fact, the payment should be structured in a way that it can grant the incentive to the sellers to provide that good and to the buyers to compete with the cost of alternative means of securing the desired service.

Results suggest that, when considering only the carbon credits that can be sold without incurring in the double-counting (i.e. within the actual policy framework), an output-based payment, though more environmentally efficient, could not be enough to incentivise farmers to join the PES, as the payment per hectare might be lower using this approach.

Thus, in this contest there seems to be small opportunity for the market to emerge, unless there are other funds (i.e. RDPs) that can compensate the operational costs or buyers don't commit themselves to pay a higher price (than the minimum in alternative markets) for a ton of CO_2 sequestered in soils.

Regardless of the approach adopted, i.e. payment for direct ES outputs or management practices, results show the need for further research to overcome technical issues and also to reach consensus among PES actors in order to build a robust programme. Progress of research field and stakeholders engagement, could then be translated in the climate policy framework. In fact, as stated by Engel *et al*. (2008) PES mechanisms "are not created in a vacuum by social planners or economic theorists. They develop in particular environmental, economic, social, and political contexts, and are subject to the push and pull of many stakeholders" (*ibid*., p. 668).

Once that soil C sequestration shows to be effective and cheaper than the least expensive measure currently used to meet climate policy targets, it could be efficient to propose climate policy framework changes in order to allow soil carbon offset credits.

References

ARPAV (2005). Carta dei suoli del Veneto. Grafiche Vianello. Ponzano (TV).

Benton, T. (2012). Managing agricultural landscapes for production of multiple services: the policy challenge, *Politica Agricola Internazionale - International Agricultural Policy*, 2012, Issue 1: 7-17.

Capitanio, F., Adinolfi, F. & Santeramo, F.G. (2014). Environmental implications of crop insurance subsidies in Southern Italy. *International Journal of Environmental Studies*. DOI: 10.1080/00207233.2014.947737.

Castro, J., Fernández-Ondoño, E., Rodríguez, C., Lallena, A.M., Sierra, M. & Aguilar, J. (2008). Effects of different olive-grove management systems on the organic carbon and nitrogen content of the soil in Jaén (Spain). *Soil and Tillage Research* 98(1): 56-67.

Coderoni, S. & Bonati, G. (Eds.) (2013). ICAAI- Impronta Carbonica Aziende Agricole Italiane. Working Paper, ISBN 978-88-8145-246-0, National Institute of Agricultural Economics (INEA), Rome.

Coderoni, S., Bonati, G., D'Angelo, L., Longhitano, D., Mambella, M., Papaleo, A. & Vanino, S. (2013). Using FADN data to estimate agricultural greenhouse gases emissions at farm level, in Vrolijk, H., Pacioli 20 (Eds.), *Complex farms and sustainability in farm level data collection* (pp. 13-054), LEI Proceedings.

Coderoni, S., Longhitano, D. & Vinci, A. (2013). Contabilizzare il contributo dell'agricoltura alla mitigazione delle emissioni di gas serra. Una possibile metodologia di stima per i sink di carbonio negli agrosistemi olivicoli mediante la Rete di Informazione Contabile Agricola. *Territori. Strumenti interdisciplinari per la valutazione, la programmazione e la gestione delle risorse ambientali.*18/2013: 6-10 ISSN 2039806-9.

Council of the European Union (2013a). Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 1698/2005), Brussels, 17 December 2013.

Council of the European Union (2013b). Regulation (EU) No 1307/2013 of the European Parliament and of the Council establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy, Brussels, 17 December 2013.

Dobbs, T.L. & Pretty, J. (2008). Case study of agri-environmental payments: the United Kingdom. *Ecological Economics* 65, 765–775 (this issue). Doi:10.1016/j.ecolecon.2007.07.030.

Engel, S., (2007). *Payments for Environmental Services: Potentials and Caveats*. IED Newsletter No. 1. Institute for Environmental Decisions. ETH, Zürich.

Engel S., Pagiola S. & Wunderc S. (2008). Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics* 65 (2008): 663-674.

Facini, O., Georgiadis, T., Nardino, M., Rossi, F., Maracchi, G. & Motisi, A. (2007). Il contributo degli impianti da frutto all'assorbimento della CO_2 atmosferica. In: Carli B., Cavarretta G., Colacino M, Fuzzi S. (Eds.) (pp.663-668). *Clima e Cambiamenti Climatici: le attività del CNR*, Roma.

Ferraro, P.J., & Pattanayak, S., (2006). Money for nothing?A call forempirical evaluation of biodiversity conservation investments. *PLoS Biology* 4 (4), e105.

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

Hardin, G. (1968) The Tragedy of the Commons, *Science*, Vol. 162, No. 3859 (13 December 1968), pp. 1243–1248.

INEA, (2014). Lo Stato del Mercato Forestale del Carbonio in Italia 2012, ISBN 9788881453276, INEA, Rome.

IPCC (2001). Climate Change 2001: Mitigation - Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) [Metz, B., O. Davidson, R. Swart, and J. Pan (Eds.)]. Cambridge University Press, Cambridge, 700 pp.

IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories.Prepared by the National Greenhouse Gas Inventories Programme. Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Eds.). Published: IGES. Japan.

ISMEA, (2012), Indagine sui costi di produzione delle olive da olio. Piano di Settore olivicolo-oleario, Rome, July 2012 (available online at the following url: http://www.pianidisettore.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/697#5b4134 last access on October 2014).

ISPRA (2014*), Italian Greenhouse Gas Inventory 1990-2012. National Inventory Report 2014*. Institute for Environmental Protection and Research - ISPRA, Report 178/2014, Rome.

Jack, B.K., Kouskya, C. & Simsa, K.R.E. (2008).Designing payments for ecosystem services: Lessons from previous experience with incentive-based mechanisms. *PNAS* 105(28): 9465-9470.

Marangon, F. & Troiano, S. (2013). New tools for the EU agricultural sector and rural areas. What role for public policy in promoting Payments for Ecosystem Services*? Politica Agricola Internazionale - International Agricultural Policy*, 2013, issue 2.

Márquez-García, F., González-Sánchez, E. J., Castro-García, R. & Ordóñez-Fernández, R. (2013). Improvement of soil carbon sink by cover crops in olive orchards under semiarid conditions. Influence of the type of soil and weed. *Spanish journal of Agricultural Research* 11 (2) : 335-346.

Matthews, A. (2014). Incentivising soil carbon sequestration, posted on Cap Reform on 04 Apr 2014. (url: http://capreform.eu/incentivising-soil-carbon-sequestration/ accessed on October 2014).

Muradian, R., Corbera, R., Pascual, U., Kosoy, N. & May, P.H. (2010). Reconciling theory and practice: an alternative conceptual framework for understanding payments for environmental services. *Ecological Economics* 69(6):1202-1208.

Nardino, M., Pernice, F., Rossi, F., Georgiadis, T., Facini, O. & Motisi, A. (2013). Annual and monthly carbon balance in an intensively managed Mediterranean olive orchard. *Photosynthetica* 51(1): 63-74.

OECD (1998), Co-operative Approaches to Sustainable Agriculture, OECD, Paris.

OECD (2010), Paying for biodiversity: enhancing the cost-effectiveness of payments for ecosystem services. ISBN 978-92-64-09026-2,OECD, Paris.

Ostrom, E. (2003). How types of goods and property rights jointly affect collective action. *Journal of Theoretical Politics* 15 (3): 239–270.

Pagiola, S. (2005). Assessing the Efficiency of Payments for Environmental Services Programs: a Framework for Analysis. World Bank, Washington.

Pagiola, S. & Platais, G., (2007). Payments for Environmental Services: From Theory to Practice. World Bank, Washington.

Pagiola, S., Arcenas, A. & Platais, G. (2005). Can payments for environmental services help reduce poverty? An exploration of the issues and the evidence to date from Latin America. *World Development* 33: 237–253.

Palese, A. M., Pergola, M., Celano, G. & Xiloyannis, C. (2013). L'oliveto sostenibile per il sequestro di CO_2. *L'informatore Agrario* 34: 44-46.

Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., McCarl, S., Ogle, S., O'Mara, F., Rice, C., Scholes, B. & Sirotenko, O., (2007). Agriculture. In Metz, B., Davidson, O.R., Bosch, P.R., Dave, R. and Meyer, L.A. (Eds.), *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp.499-531), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA..

Smith, P., Powlson, D.S., Glendining, M.J. & Smith, J. (1997). Potential for carbon sequestration soils: preliminary estimates for five scenarios using results from long-term experiments. *Global Change Biology* 3: 67-79.

Smith, S., Rowcroft, P., Everard, M., Couldrick, L., Reed, M., Rogers, H., Quick, T., Eves, C. & White, C. (2013). Payments for Ecosystem Services: A Best Practice Guide. Defra, London.

Swart, J.A.A., (2003). Will direct payments help biodiversity? *Science* 299: 1981-1982.

UNFCCC-United Nations Framework Convention on Climate Change, (2006). Modalities and Procedures for Afforestation and Reforestation Project Activities Under the Clean Development Mechanism. Montreal: 61. http://unfccc.int/resource/docs/2005/cmp1/eng/08a01.pdf#page=61

Wunder, S. (2005). *Payments for environmental services: Some nuts and bolts*. Center for International Forestry Research Occasional, Paper No. 42 [online] available at: www.cifor.org/publications/pdf_files/OccPapers/OP-42.pdf.

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