Addressing the demand for and supply of ecosystem services in agriculture through market-based and target-based policy measures

Doctoral dissertation

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Contents

Abstract

Agricultural lands are managed or modified ecosystems that interact with the surrounding natural ecosystems in order to supply but at the same time use a great range of ecosystem services (ES). In addition, agriculture is responsible for disservices that negatively affect natural ecosystems. In Finland, agricultural lands have undergone marked changes affecting the state of the ecosystem, and as a consequence the flow of a great number of vital ES. Traditional agri-environmental policy has been criticized for being inefficient in ensuring the provision of ES or limiting the disservices, while the public character of some ES has resulted the inability of the market to reflect the demand for or supply of ES. Market-based mechanisms as well as targeted policy measures may ensure effective and efficient ES provision. By using the framework of ES, this dissertation explores the factors that determine the citizen demand for and landowner supply of ES, and considers examples of market- and target-based measures that may supplement or replace the current form of agri-environmental policy.

The first part of the dissertation is focused on the demand for and supply of cultural ES provided by agricultural lands. Traditional agri-environmental policy does not account for the local needs and has being inadequate in capturing the demand for certain locally relevant landscape attributes. At the same time, due to the public character of ES, demand is not reflected in the markets, leading to underprovision. The first two studies of this dissertation applied a choice experiment to evaluate a market-based scheme, i.e. a Payment for Ecosystem Services (PES) scheme that provides certain landscape attributes in a typical agricultural area. The data from a municipality-level case study in southern Finland revealed that the most valued attributes were the renovation of production buildings and the presence of grazing animals. Accounting for heterogeneity, both studies demonstrated that citizen preferences are heterogeneous, a fact which may affect the level of transaction costs and consequently the performance of the scheme. Moreover, the results highlight the significant hesitancy from the supply side, as a significant share of landowners are skeptical towards the scheme, willing to provide ES that do not always match with the demand, and finally demand compensation in excess of their expenses. Despite this, a cost–benefit approximation analysis revealed that the scheme may be feasible, as the aggregated welfare benefits outweigh the anticipated costs.

The second part of the dissertation is focused on the supply of water conservation services and the avoidance of water eutrophication disservices. Finnish agri-environmental policy sets equal incentives for water conservation, not accounting for environmental conditions, which are spatially varied. Before suggesting any policy reform and the use of alternative measures such as target-based measures, where farmers are compensated for delivering certain ES, it is imperative to investigate the tendency of landowners to adopt water conservation measures.

The third study examined the adoption of conservation measures if the soil quality implies a high leaching risk and if the water quality is already poor. By combining survey data with GIS data, the effect of farm and farmer characteristics and attitudes towards adoption were examined. For active farmers, the likelihood for adopting measures was found to be significantly determined by financial variables, while for landowners who are passively engaged in farming, the likelihood is also affected many attitudinal factors. Surprisingly, adoption in areas under risk was weakly supported by the study's estimates, indicating that environmental awareness, assuming it increases with risk, is not strong enough to motivate adoption. The study concluded that target-based measures, even though costly, cannot be avoided, and spatially tailored measures can attract adopters in hotspot areas.

The latter outcome leads to the subject of the last study, which examines farmers' participation in an agri-environmental auction (AEau) scheme. The study employed data from an auction experiment conducted in Nurmijärvi, southern Finland, and accounted for socio-demographic, spatial and attitude variables. Large-scale farmers were more likely to have participated in the auction experiment, while older farmers, those engaged full time in farming, and less well-trained farmers were less likely to be positive towards future auctions. Past participation was positively and significantly related to prospective auctions. The findings suggest a strong relationship between attitudes and participation, particularly for attitudes related to specific environmental benefits attached to the auction scheme, novelty and financial features, as well as the complexity of the auction mechanism.

The ES examined in this dissertation, i.e. landscape amenities and water eutrophication disservices, are of priority given the stresses that the Finnish agricultural landscape has experienced during the past years and the eutrophication issues of water bodies, which also largely affect the state of the Baltic Sea. The empirical research findings enhance current knowledge in planning market- and target-based schemes in the years to come. These schemes are attracting increasing attention for being more effective and, if properly designed, more efficient. For $AEau_s$ in particular, the findings are novel, since they were derived from the first auction experiment ever implemented in Finland.

Keywords: agro-ecosystem services, agricultural landscape preferences, water conservation behavior, payment for ecosystem services, agri-environmental auctions, choice experiment

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List of articles

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Author's contribution

Ioanna Grammatikopoulou performed the statistical analysis and the largest part of literature review in all articles. Ioanna Grammatikopoulou was the corresponding author of all the articles. All co-authors participated in editing the articles throughout all rounds of publication revision.

For article I, Eija Pouta and Maija Salmiovirta planned the survey and Samliovirta implemented the data collection. Eija Pouta and Katriina Soini provided the research idea. The econometric specification was jointly developed by Ioanna Grammatikopoulou and Eija Pouta. For article II, Maija Salmiovirta planned and implemented the data collection. Ioanna Grammatikopoulou and Eija Pouta provided the approach of the analysis. The econometric specification was jointly designed by Ioanna Grammatikopoulou and Eija Pouta. For article IV, Eija Pouta and Sami Myyrä provided the research idea and organized the data collection. Eija Pouta and Ioanna Grammatikopoulou contributed to the analysis approach. For article V, Antti Iho planned and implemented the data collection and provided the research idea. Eija Pouta and Ioanna Grammatikopoulou contributed to the analysis approach. The econometric specification was formed by Ioanna Grammatikopoulou.

List of abbreviations

AEau	Agri-environmental auction
AEP	Agri-environmental program
ASC	Alternative specific constant
CE	Choice experiment
CL	Conditional logit
ES	Ecosystem services
IIA	Independence from irrelevant alternatives
IID	Independently identically distributed
LCA	Latent class analysis
LR	Likelihood ratio
MBS	Market-based scheme
MLE	Maximum likelihood estimation
MNL	Multinomial logit
Relogit	Rare events logit
RPL	Random parameters logit
RUM	Random utility model
TBS	Target-based scheme
PES	Payment for ecosystem services
WTA	Willingness to accept
WTP	Willingness to pay

1. Introduction

1.1 Agricultural land as an ecosystem and its ecosystem services

Agricultural land constitutes a managed or modified ecosystem (Sandhu et al., 2013; Ma and Swinton, 2011; Sandhu and Wratten, 2013) that provides ecosystem services (ES) essential to human well-being (Ma and Swinton, 2011). ES are the "benefits that people obtain from ecosystems" (MEA, 2005) and are classified into four groups, i.e. supporting, regulating, provisioning, and cultural ES (Costanza et al., 1997; de Groot et al., 2002; MEA, 2005; TEEB, 2010). An agricultural ecosystem interacts with the surrounding natural ecosystems and provides provisioning ES such as food, fiber and biofuels, regulating ES such as services to regulate water quality and quantity, supporting services such as nutrient cycling and soil formation, and finally, recreational, aesthetic and cultural ES. Moreover, agriculture requires ES, such as soil fertility to use as inputs in agricultural production. An agricultural ecosystem also negatively affects the state of other natural ecosystems by generating negative externalities, which in the ES framework are called disservices. Soil erosion, the eutrophication of water bodies, biodiversity loss and the loss of rural culture are some common examples of disservices from agriculture (Stallman, 2011; Zhang et al., 2007; Ma and Swinton, 2011).

The framework of ES intends to identify and manage services, as well as disservices, from agriculture (Huang, et al., 2015). It aims to disentangle the ways in which policy makers, stakeholders, and citizens perceive agriculture and ensure that agricultural lands are properly managed so that more and higher quality ES are guaranteed. This insight may substantially increase the long-term sustainability of agricultural ecosystems, as well as of the surrounding natural ecosystems, and reduce the environmental damage caused by farming activities (Stallman, 2011; Tillman et al., 2002).

1.2 Finnish agriculture in transition and the impact on ecosystem services

Finnish agriculture and the agricultural landscape have undergone a transition due to significant changes in cultivation systems, urban settlement, energy production and delivery, as well as land abandonment. In southern and western parts of the country, the landscape is losing its diversity as a result of agricultural intensification (Hietala-Koivu, 2002), while, in northern and eastern parts, the agricultural landscape is facing the pressure of afforestation. Moreover, natural surroundings (forests and wetlands) make the field plot structure quite fragmented, while this structure is deteriorating even further due to the fact that 3% of farms abandon farming annually (Myyrä and Pouta, 2010). Furthermore, the proportion of land under lease contracts has doubled within the last 15 years. Land leasing is an important land-use option, which promotes intensification and provides an alternative for those who are giving up farming. In Finland, land use under leasing accounts for 33% of the agricultural land area.

These transitions have affected agriculture's ability to produce ES such as landscape amenities, but also its involvement in generating disservices such as erosion and eutrophication. Landscape amenities have deteriorated due to the loss of diversity of the scenery. This is a severe change considering that agricultural lands enhance the visual quality of the open landscape (Rechtman, 2013), and for a country of forests such as Finland it is even more valuable. Agricultural areas provide vital amenities for people as a close-to-home recreation environment, accounting for 180 million day trips annually (Pouta & Ovaskainen, 2006). Erosion and nutrient run off (mainly phosphorous and nitrogen leaching) are negative externalities that arise from the intensification of agriculture and affect water bodies between the farms and the Baltic Sea, as well as the condition of the Baltic Sea itself. The increase in lease contracts has worsened the state of water bodies and eutrophication incidents, as the responsibility for water conservation is now shared between lease holders and active farmers.

1.3 Market and agri-environmental policy gaps vis-à-vis ecosystem service provision

Cultural and regulating ES from agriculture pursue the attributes of public goods, i.e. non-excludability and non-rivalry. Markets normally fail to provide such services, since their value and consequently their demand is not reflected in the markets. Moreover, their supply depends on private initiatives, and landowners are not always motivated to account for ES supply during their decision making (Kroeger and Casey, 2007). This holds even more when off-farm environmental benefits are associated with landowners' actions.

Traditional[1] agri-environmental programs (AEPs) aim to ensure that agriculture will continue to provide public goods (Primdahl et al., 2010), overcoming the incompetence of markets. However, there are cases where policy schemes have also failed to develop socially efficient measures for ES attached to certain environmental and societal needs (Hasund, 2013; v. Haaren and Bathke, 2008).

The Finnish AEP, with reference to the first three program periods, i.e. 1995–1999, 2000–2006, and 2007–2013, has addressed several environmental issues such air and water quality, biodiversity and landscape. The AEP requires that the landscape should be kept open and managed, while farmers can apply for special support if they provide landscape diversity.

Nonetheless, the Finnish AEP does not always suit to the local conditions, as it is often the case that certain landscape attributes that local people may favor are not included in the policy scheme. Policy schemes do not guarantee the production of public goods such as recreational opportunities in agricultural landscapes (Pouta and Ovaskainen, 2006), even though landscape management is included in the general AEP over a nationwide range (Kaljonen, 2006).

Improving surface water quality has been the priority of the Finnish AEP, but its contribution to water conservation is still poor. The AEP sets equal incentives for water conservation, independently of the eutrophication risk caused by the farming activity. Such policy planning has been criticized for being inefficient, since the most degraded areas could lead to greater conservation benefits (Lankoski and Ollikainen, 2003). The phosphorous load per hectare of cropland has slightly decreased in each AEP period (Aakkula and Leppänen, 2014) while nitrogen run off has increased (Lankoski and Ollikainen, 2013). On top of that, cropland areas are increasing and the nitrogen load to waterways from agriculture has continued to grow.

In addition, AEP schemes only focus on active farmers, ignoring passive landowners who are leasing out their land. This is a crucial element given the current development, where the population of non-active (or passive) landowners is growing and their management decisions may still affect landscape services (Pouta et al., 2012).

1.4 Ecosystem service provision through market- and target-based schemes

Due to market failure and policy inefficiency, alternative policy measures are needed such as market-based schemes (MBSs) and target-based schemes (TBSs). These schemes are structured based on the ES framework and on the evidence that ES contain values that are measurable and visible in a demand–supply market context.

[1] The term 'traditional' refers to the form of program that was introduced as part of the 1999 Common Agricultural Policy (CAP) reform, and which was later incorporated into the Rural Development Programs of member states.

MBSs are policy tools that aim to motivate the involved actors through market signals, as opposed to specific regulations in command and control approaches (Stavins, 2000). These tools facilitate the provision of environmental and public goods when the market and governments fail to do so. There are several ways to categorize MBSs, but the most usual approach is to distinguish between price-based, quantity-based, and market-friction MBSs (Whitten and Coggan, 2013).

TBSs or results-oriented schemes comprise cost-effective alternatives that aim to replace or supplement the action-based schemes that even until recently dominated the AEP. Farmers receive payments according to their effort in providing certain environmental outcomes, and more than that, by developing innovative skills and knowledge to attain the best results in more cost-efficient ways. In principle, these measures are MBSs that have been suggested to replace the traditional action-based schemes, but due to certain risks and problems, among which are the high administration and transaction costs, they should be better viewed as "a mix of AEP strategies to be targeted at particular situations and not applied unilaterally" (Burton and Schwarz, 2013).

1.5 Objectives

This dissertation is focused on the demand for and supply of ecosystem services that are provided by Finnish agriculture, and in particular on cultural services that are provided as agricultural landscape amenities, as well as on regulating services and disservices respectively related to soil retention and water purification and to eutrophication and nutrient run-off.

The study examined the performance of two schemes: a Payment for Ecosystem Services (PES) scheme representing MBSs and an agri-environmental auction (AEau) scheme representing MBSs. The overall objective of the studies was to explore the factors that determine the demand for and supply of these services from agriculture by employing choice experiments based on the random utility model (RUM) framework and exploring the choice decision-making process of associated actors. The outcomes of the studies provide insights for designing MBSs and TBSs, and in particular for a PES and AEau scheme. According to the current research inputs, these schemes are considered highly promising and, if properly designed, may overcome the inefficiencies in ES provision that arise due to market failure and policy gaps. Nonetheless, the literature is still poor and more empirical studies are needed to enhance current knowledge regarding the performance of these schemes. This thesis study aimed to investigate whether the implementation of case-specific schemes is feasible, and to report aspects of policy relevance that can be taken into consideration during the planning phase.

The dissertation is comprised of four studies. Studies I and II considered the provision of landscape amenities and Study III and IV examined the provision of water quality ES, as well as disservices from eutrophication risks.

Studies I and II investigated citizen preferences for landscape improvements in a typical agricultural landscape setting. A considerable number of studies have focused on distinctive rural or agricultural landscapes due to their significant ecological, historical, cultural, or political value (e.g. Arnberger and Eder, 2011; Campbell, 2007; Colombo et al., 2009), although studies focusing on representative agricultural production landscapes are rare in the literature. In addition, these studies explore critical issues that may affect the design and performance of a locally implemented PES scheme. These issues concern the presence of heterogeneity in citizen preferences, the level of acceptance of the scheme and the willingness of landowners to participate in improving certain attributes. The thesis studies aimed to reveal welfare considerations, i.e. the aggregate benefit and cost considerations that will eventually anticipate whether the scheme is feasible, and also stress the challenges that actors need to account for during the design phase. Literature inputs regarding PES schemes for agricultural landscape services are quite scarce. Moreover, Study II brought together social provision (landowner perspective) and demand (citizen preferences), hence examining the feasibility aspect of the scheme from a more spherical approach.

Studies III and IV explored the determinants of adopting water conservation measures for both actively engaged farmers (hereafter named active owners) and non-actively engaged landowners (hereafter named passive owners). The core question of Study III was whether the state of biophysical characteristics of the farm affects the adoption of voluntary water conservation measures, and whether landowners who operate in areas where water quality is at risk are more eager to participate in these measures. This is a critical matter that has emerged following the suggestion of introducing TBSs in order to supplement or replace the current traditional agri-environmental measures. TBSs are costly schemes and their contribution is only justified if this natural tendency does not hold. According to findings from previous studies, the voluntary adoption of measures may be effective in case of a deteriorated state of biophysical farm characteristics (Lambert et al., 2007; Pautsch et al., 2001), but the presence of this effect is unclear in the case where the benefits of conservation are mostly public. Moreover, past research has revealed differences in the adoption of conservation measures between landowner types (Soule et al., 2000).

In relation to the introduction of TBSs, Study IV explored the profile of participants in voluntary AEau$_s$. In particular, the study holistically examined all factors that may affect participation in a pilot auction, as well in future auctions. It also intended to shed light on the motives, objectives, and behaviors of landowners and outline the profile of adopters who would be more receptive to AEau$_s$, allowing for policies to be more efficiently implemented. Most of the literature in relation to the behavior of farmers in AEau$_s$ limits itself to exploring the factors underlying bidding behavior (e.g. Moon and Cocklin, 2011; Jack et al., 2008), ignoring the part of the decision process before farmers decide whether to participate in the auction.

2. Literature review

To achieve the sustainable development of ecosystems, the supply of as well as the demand for ES should be accounted for. This is a key message arising from up-to-date research in relation to the management of natural and managed ecosystems (e.g. Castro et al., 2014, Nieto-Romero et al., 2014; Zasada, 2011), and which is also in line with the ES framework (Huang et al., 2015). The demand can be addressed by using non-monetary indicators (e.g. people's perceptions of the value/importance of ES) and/or by using economic indicators derived from real or hypothetical markets (Martín-López et al., 2012; Turner et al., 2010). The supply is related to farmers' willingness to adopt landscape management practices and farming procedures (e.g. organic farming or extensive management) that would promote ES such as amenities, as well as soil and water protection (Zasada, 2011). The outline of demand and supply will entail the identification (profile, preferences and valuation of ES) of beneficiaries, as well as of providers, to ensure socially efficient management of ES, solving the problems of underprovision or mismatching of ES (Pagiola et al., 2005).

2.1 Citizen demand for cultural services provided by the agricultural landscape

Landscapes are shaped by the presence (or absence) of several attributes for which people may have preferences regarding changes what will either affect the status of the landscape in general or the state of particular attributes. The demand for cultural ES that are provided through the presence of landscape attributes refers to the value that individuals place on the state of certain ES and/or on proposed changes aiming at ES improvements. The value is attached to certain preferences, and thus demand incorporates both the value of and preferences for ES. Past literature has highlighted the importance of landscape attributes such as farm buildings, the presence of animals, the management of vegetation and of field boundaries, and the presence of biotopes and native species (Rambolinaza and Dachary-Bernard, 2007; Scarpa et al., 2007; Campbell, 2007; Sayadi et al., 2005 and 2009; Colombo et al., 2009; Howley et al., 2012).

For cultural ES that are provided by the agricultural landscape, the demand is rarely homogeneous and several studies have opposed the 'consensus assumption' (Van Den Berg et al., 1998) regarding landscape perceptions and preferences. People may state different and sometimes contradictory preferences, since landscape ES are complex themselves, and also because the individual background affects landscape preferences. The place of residence (Campbell, 2007; Colombo et al., 2009), age (Campbell, 2007; Howley et al., 2012; Colombo et al., 2009), gender (Campbell, 2007; Howley et al., 2012), education (Colombo et al., 2009; Arnberger and Eder, 2011), childhood (Arnberger and Eder, 2011), environmental attitudes (Howley et al., 2012), and social perceptions (Arnberger and Eder, 2011) are some of the variables that have been investigated in rural and agricultural landscape studies. People can also form groups that carry homogeneous preferences, and some studies have approached this heterogeneity by investigating predefined groups (e.g. Rambolinaza and Dachary-Bernard, 2007; Willis et al., 1995).

By investigating demand and the heterogeneity in preferences, researchers can shed light on some important issues. Firstly, it is crucial to determine whether MBSs will result in a positive or a negative welfare change. Secondly, in the case of heterogeneity, some people may be interested in the proposed scheme, while others may not be interested at all. Hence, heterogeneity will reveal the share and the profile of both the 'winners' and the 'losers', as well as the respective level of change in their welfare. The latter is an important outcome in order to advocate the social equity of the scheme.

2.2 Landowner decision making and the supply of water regulating services

The provision of ES from agricultural lands depends on the willingness of landowners to participate in MBSs or TBSs. The literature usually refers to farmers, i.e. to active landowners who are professionally engaged in farming. However, given the specific context in each country and the current trends, it is sometimes useful to also account for passive landowners, who are leasing out their land but who still bear responsibility for the preservation of ES (Grammatikopoulou et al., 2012c and 2015).

Based on suggestions provided by prior studies (Ervin and Ervin, 1982; Lynne et al., 1988; Vanslembrouck et al., 2002; Defrancesco et al., 2008; van Putten et al., 2011; Knowler and Bradshaw, 2007), the general conceptual framework of landowner participation in conservation measures may be summarized in the following list of factors: a) choice-specific, i.e. attributes of the conservation program/scheme (e.g. Moon and Cocklin, 2011) or of the provided ES and/or the level of compensation (e.g. Grammatikopoulou et al., 2013; 2012[b]), b) individual-specific characteristics, c) farm-specific characteristics, d) the presence and level of information sources[2] (e.g. Frondel et al., 2012), and e) exogenous factors such as external macro-level factors (e.g. Stuart and Gillon, 2013). For a detailed description regarding the literature background of the conceptual framework, the reader may refer to the following sources: Grammatikopoulou et al. (2012[b,c] and 2015).

Individual-specific attributes can be decomposed into socio-demographic and financial characteristics (Defrancesco et al., 2008; Vanslembrouck et al., 2002; Langpap, 2004; Luzar and Diagne, 1999; Lynch and Lovel, 2003), familiarity or previous experience (Ajzen, 2002; Wynn et al., 2011), and the attitudes of landowners (e.g. Vanslembrouck et al., 2002; Langpap, 2004; Luzar and Diagne, 1999). A considerable number of recent studies have emphasized the strong predictive power of landowners' behavioral and attitudinal factors (e.g. Lynne et al., 1988; Luzar & Diagne, 1999; Vanslembrouck et al., 2002; Defrancesco et al., 2008; van Putten et al., 2011), arguing that financial factors are not sufficient to capture the complex decision making of landowners. Landowners are not strictly profit-maximizing operators as were traditionally met (Sheeder and Lynne, 2009), partly due to environmental and social considerations that intervene in the decision-making process. The attitudinal factors that affect landowners' behavioral patterns can be categorized into the groups below: a) attitudes towards conservation goals, environmental protection, or public environmental benefits, environmental awareness and active engagement in environmental issues, b) values and attitudes related to engagement in farming or owning land *per se*, intrinsic and social values of land ownership and of farmership (Emtage and Herbohn, 2012; De Young, 2000), c) attitudes towards the project or the scheme itself, its design, organization and objectives, its difficulty in terms of applying practices, innovation aspects, competence and trust in authorities who have the administrative role (Moon and Cocklin, 2011; Korhonen, 2013; Mäntymaa et al., 2009), and d) attitudes towards social norms and social approval (Defrancesco et al., 2008;Wauters et al., 2010), or e) towards the regulatory power of a scheme (Langpap, 2004).

Farm-specific attributes are comprised of the characteristics of the property or farm (e.g. Lynch and Lovell, 2003; Vanslembrouck et al., 2002), property location (e.g. Lynch and Lovell, 2003; Raymond and Brown, 2011), and biophysical/resource characteristics and their state (e.g. Maybery et al., 2005; Amsallu and Graff, 2007). To describe the state of the resource, some studies have used subjective measures[3], such as the perception or recognition of the environmental problems (Amsallu and Graff, 2007; Cary and Wilkinson, 1997; Cooper, 1997), or estimates of farm characteristics related to environmental degradation, e.g. the level of slope (Bekele and Drake, 2003; Amsallu and Graff, 2007). On the other hand, other studies have attempted to include objective measurements such as erodibility indices (Lampert et al., 2007), or to use national resources inventory data (Pautsch et al., 2001). According to earlier research results, the sensitivity of soils has not had a significant effect on providing soil and water conservation (Nyangena, 2008), whereas some other studies have demonstrated contradictory results (e.g. Clay et al., 1998; Lampert et al., 2007). Moreover, even if there is a link between a resource's state and conservation behavior, the conservation motive may not be clear, as it may be related to lower agricultural productivity and not necessarily to environmental risks (e.g. Hynes and Garvey, 2009; Dupraz et al. 2003).

[2] The 'information' factor may be choice or individual specific. In the first case, the presence or level of information would be an attribute of the conservation scheme itself, while in the latter case, it would refer to an individual's subjective perception of the available information sources.

[3] In this case, the factor is individual specific and depicts the perception of the environmental state. The perception leads to a level of awareness and attitude towards environmental protection, which in turn results in actual behavior (Sinden and King, 1990).

It is important to acknowledge the determinants other than the size of monetary compensation, of participation in voluntary measures such as PES or AEaus during the policy design process, as this allows for policies to be better targeted at those owners (or groups of owners) who are open to such measures (e.g., Maybery et al. 2005; Ross-Davis and Broussard 2007). Moreover, knowledge of the factors that affect landowner interest in conservation and eventually the provision of ES is a prerequisite to ensuring the feasibility of the policy scheme, as well as for adjusting extension services (Boon et al. 2004; Maybery et al. 2005; Kendra and Hull 2005). Given that voluntary schemes usually involve easy entry and exit, behavioral patterns and intentions should be investigated in detail for the scheme to be effective (Kauneckis & York, 2009; Mäntymaa et al., 2009) in all stages of its process, i.e. from the communication to the implementation and monitoring.

Table 1: A summary of the literature context on the factors that determine the demand for and supply of ES

Demand for landscape attributes	
Type of factors	***References***
Socio-demographic factors	
Place of residence	Campell, 2007; Colombo et al., 2009
Age	Campell, 2007; Colombo et al., 2009;Howley et al., 2012
Gender	Campell, 2007; Howley et al., 2012
Education	Colombo et al., 2009; Arnberger and Eder, 2011
Childhood	Arnberger and Eder, 2011
Attitudes	
Environmental attitudes	Howley et al., 2012
Social perceptions	Arnberger and Eder, 2011
Conservation behavior; supply of water regulating ES	
Type of factors	***References****
Choice-specific attributes	
Attributes of the conservation program or scheme	Moon and Cocklin, 2011; Grammatikopoulou et al., 2012[b], 2013
Individual-specific characteristics	
Socio-demographic, e.g. age, education, engagement in farming, existence of successors	Vanslembrouck et al., 2002; Langpap, 2004; Wynn et al., 2011; Luzar and Diagne, 1999
Financial characteristics, e.g. agricultural income, off-farm income, rental income	Defrancesco et al.,2008; Lynch and Lovell, 2003
Familiarity or previous experience	Ajzen, 2002; Wynn et al., 2011
Attitudes towards the environment, e.g. conservation goals, environmental protection and benefits, awareness of and active participation in environmental issues	Vanslembrouck et al., 2002; Langpap, 2004; Luzar and Diagne, 1999; Mäntymaa et al.,2009; Wauters et al., 2010; Defrancesco et al.,2008; van Putten et al., 2011
Values and attitudes related to farming, owning land, intrinsic and social values	Emtage and Herbohn, 2012; De Young, 2000
Attitudes towards the project or scheme, e.g. the design, innovative aspects, trust in administration	Moon and Cocklin, 2011; Korhonen, 2013; Mäntymaa et al., 2009
Social norms and approval	Moon and Cocklin, 2011; Korhonen, 2013; Mäntymaa et al., 2009
Attitudes concerning the regulatory power of a scheme	Langpap, 2004
Farm-specific characteristics	
Farm characteristics, e.g. land use, size, location	Lynch and Lovell, 2003; Vanslembrouck et al., 2002; Raymond and Brown, 2011

Biophysical/resource characteristics, e.g. soil type, level of slope	Maybery et al., 2005; Amsallu and Graff, 2007
Information related factors	
Presence and level of information sources	Frondel et al., 2012
Exogenous	
External macro-level factors: policy and market conditions	Stuart and Gillon, 2013

* The reference list has been shortened here and includes the references that summarize most of the factors as stated here. For an extended list, the reader may refer to Grammatikopoulou et al., 2012[b,c] and 2015

2.3 The policy instruments for revealing the demand and supply of ecosystem services

Payment for Ecosystem Services (PES)

PES schemes are MBSs that aim to overcome market and policy insufficiency so that public goods and services are supplied at the socially optimal level. According to Wunder (2005), a PES is "a voluntary transaction where a well-defined ES is being 'bought' by a minimum of one service buyer from a minimum of one service provider if and only if the service provider secures service provision (conditionality)." The scheme relies on private negotiations between interested parties provided that property rights are clearly defined and transaction costs are low (Coase, 1960). This is a commonly applied instrument so as to conserve natural resources, but it can be extended to the provision of benefits from semi-natural ecosystems such as AEs (Engel et al., 2008). Examples are abundant in the literature, both for developing as well as developed countries. Depending on the type of buyer, i.e. private or public, PES schemes can be *user financed*, *government financed*, or *NGO financed*. Moreover, PESs are defined according to: the type of payment (*fixed* or *flexible*), the financing arrangement (*customer* or *tax based*), and the targeting approach for valuing the services (*benefit* or *cost based*) (Ravnborg et al., 2007; Badcock et al., 1997).

The scale of a PES scheme is an important element that has to be decided on from the early stages of the scheme design. Local user-financed PES schemes have significantly better chances of being more efficient than large-scale government-financed ones. In such locally implemented schemes, the associated parties have a clear incentive to aim for a well-functioning mechanism and, moreover, to track whether the service is being delivered and re-define the terms of agreement in case this is necessary (Pagiola and Platais, 2007). Such schemes can overcome two major limitations, i.e. the incentives for *free-riding behavior* and the high *transaction costs*. Factors such as group size, the contribution of others and pro-social behavior affect free-riding incentives (Frei and Maier, 2004; Cubitt et al., 2011; Hann and Kooreman, 2002). Hence, if the number of beneficiaries is small, such as for very local cases, then it is likely that social ties among individuals will be strong enough to diminish the tendency for free riding. Moreover, the small number of associated actors keeps the transactions cost low and the mechanism's effectiveness is then secured. Nevertheless, the latter may be jeopardized by the presence of heterogeneity of preferences (Hackl et al., 2007). Moreover, sufficiently large welfare benefits (Engel et al., 2008) play a crucial role in mitigating free riding.

The payments of PES schemes are determined based on either the social benefits or the social costs, but is often suggested that information on both the benefits and the costs should be accounted for during the decision making. The perceptions and attitudes (DeGroot et al., 2010; Wätzold et al., 2008) of the actors should be taken into consideration as well. The level of the benefits will provide the upper limit of the payment level, and together with the participation rate of beneficiaries will indicate the aggregate welfare benefits. The costs comprise the opportunity, transaction, and protection costs (Wünscher et al., 2008), and their levels will provide the lower limit of the payment. If the aggregate benefits outweigh the anticipated costs, even under draft calculations (Wunder, 2007), then the scheme can be feasible. Moreover, cost–benefit analysis or considerations[4] can reveal the participation rate that will be necessary to cover the scheme's expenses when it is put into practice. This rate, if high enough, can serve as a 'safety net' against free-riding signals (Grammatikopoulou et al., 2013).

Agri-environmental auctions (AEaus)
A successful example of TBSs is AEau$_s$, which are able to tackle problems associated with heterogeneity in environmental and costs characteristics, as well as with information asymmetry between the farmer and the regulator. AEau$_s$ are likely to be more cost-efficient than traditional AESs and able to overcome the challenge of setting a proper payment for the provision of benefits (Stoneham et al., 2003).

A limited number of AEau$_s$ have been applied hitherto, and thus the experience with reference to proper design is quite short. Nonetheless, certain features of the optimal design have been investigated in many theoretical and technical papers (e.g. Myerson, 1981; Espinola-Arrendondo, 2008; Milgrom, 2004). One of these features refers to the number of participants. In order for an auction to be efficient, it has to attract a satisfactory number of participants. At the same time, auctions tend to be sophisticated schemes, implemented as a repeated measure or including multiple rounds. Auctions are often improved by refining the rules so as to achieve efficiency (at least in theoretical terms), but in this case, complexity demotivates landowners to participate (Milgrom, 2004). If landowners decide to try participating once and continue participating, the effect of the mechanism's complexity diminishes and owners start to 'learn the game'. Then, past experience facilitates participation, i.e. the number of participants increases in future auctions, but an efficiency trade-off now arises; experienced participants withhold information from the regulator, leading to information asymmetries and eventually to decayed budget efficiency, as landowners will now bid above their opportunity cost (Latacz-Lohmann and Schilizzi, 2007; Hailu and Schilizzi 2004).

AEau$_s$, as with other TBSs, are highly innovative, and landowners and/or farmers do not always feel confident in participating (e.g. Defrancensco et al., 2008). Landowners behave heterogeneously, and hence the identification of those who may be more eager for policy innovations is crucial during the scheme's design (e.g. Mayberry et al., 2005; Ross-Davis and Broussard, 2007). Only a few studies have examined farmer behavior and motives in conservation auctions (e.g. Jack et al., 2008; Vukina et al., 2008; Reeson et al., 2011; Moon and Cocklin, 2011). A notable outcome is that that farmers value more highly the environmental benefits of the scheme that directly affect land productivity and less the public benefits. On the other hand, Moon and Cocklin (2011) examined the motivations and the barriers to participation, concluding that participants rate highly those production benefits that are simultaneously accompanied by conservation benefits. Most previous studies have focused on the underlying bidding behavior, skipping the factors that affect the decision process in its early stage, i.e. the stage of deciding whether to participate.

[4] Cost–benefit considerations serve as a proxy of cost–benefit analysis, since the estimates are based on speculations.

3. Theory and methods

3.1 Measurement and modeling choices

Discrete choice framework

A discrete choice framework refers to a decision making process where an agent (e.g. an individual, a household, or a firm) faces a series of alternatives over time or different states among a set of options (or else choice sets). The outcome variable, i.e. the decision made, is a discrete variable that takes a countable number of values. The set of alternatives has to satisfy three conditions in order to be compatible with the discrete choice framework, i.e. the alternatives must be *mutually exclusive*, in that the choice of one alternative excludes the choice of any of the rest, be *exhaustive*, namely all possible alternatives are included, and *finite*. The first and the second conditions can usually be attained, as the researcher can structure the choice sets to be so, but the third condition is restrictive, as it is this very condition that distinguishes discrete choices from continuous-outcome ones (Train, 2009). Discrete choices are less informative than continuous-outcome choices, demanding more sophisticated and stimulating econometric models such as logit, probit and mixed logit models.

The simplest version of a choice setting is a binary setting, where respondents choose between two alternatives. Typically, this setting takes the form of a 'yes' or 'no' answer. In this case, the choices are modeled by employing binary models such as logit or probit models. However, it is more common that respondents are asked to decide from a wider range of alternatives through a more complex decision process. A method widely used to analyze people's preferences when choosing among competing alternatives is the choice experiment method. Multinomial models such as conditional logit or mixed logit models are used to model such preferences.

Choice experiments

The choice experiment (CE) method originates from marketing and transport research, but has recently been employed in other disciplines, such as environmental economics. It is a questionnaire-based technique[5] aiming to reveal individual preferences directly related to the good in provision. CE (as well as the contingent valuation method) is in line with economic theory, and its results can be translated in marginal value terms, i.e. marginal willingness to pay (WTP) or willingness to accept (WTA), which are of use in cost–benefit analysis contexts (Bateman et al., 2002). This method provides certain advantages when evaluating pubic goods for which there is no direct market price indicator, and it may encompass both use and non-use values of pubic goods.

The CE method is based on the idea that choices are described in terms of their attributes and the levels these attributes can take. Respondents are presented with a set of choices, each of which is described by different levels of preselected attributes, and they are asked to choose the one they most prefer. A monetary attribute representing the cost of the choice is included in the list of attributes for each choice in the choice set. A *status quo* alternative is also part of the choice sets, reflecting the baseline or 'no change' situation free of cost. In this way, respondents face a tradeoff between

[5] Questionnaire-based techniques in environmental economics are followed in line with the stated preference method. Contingent valuation and choice experiment are the most common techniques in stated preference methods.

preferred changes and the cost of making these changes. The data that represent a sequence of choices by each respondent are referred to as panel data[6].

3.2 Random Utility Model

The random utility model (RUM), developed by McFadden (1974), is the theoretical framework for modeling the process of choice in decision making. The model suggests that a decision maker *n* faces a set of mutually exclusive alternatives, $j = 1, 2, \ldots, J$. For each alternative, a certain level of utility U_{nj} can be obtained. Discrete choice models, i.e. discrete, mutually exclusive alternatives, comply with the principle that the decision maker will choose the alternative that maximizes his/her utility based on the attributes of alternatives as well as the taste of the individual. Researchers cannot directly observe the level of utility U_{nj}, as the utility function is decomposed into two separable parts: a) a deterministic part V_{nj}, which is a function of the measured and observed attributes of the alternatives and/or the individual (Train, 2009; Hanley et al., 1998), and b) a stochastic part $\varepsilon_{nj} \quad \forall\ j$ that represents unobserved attributes, heterogeneity in taste, measurement errors, and functional misspecification (Baltas and Doyle, 2001). Thus, the RUM model can be expressed as

$$U_{nj} = V_{nj} + \varepsilon_{nj} = V(x_{nj}, z_n) + \varepsilon_{nj}$$

where x_{nj} is the vector of attributes of the alternative j, z_n is the vector of characteristics of individual n , and ε_{nj} is the error term. Since the error term is not observed, what is derived is the probability of an outcome and not its exact prediction. The unobserved term is considered random, which follows a density function $f(\varepsilon_{nj})$. Different discrete choice models can be employed from different specifications of density.

The decision maker will prefer alternative i over j only if $U_{n,i} > U_{n,j}$ or $V_{n,i} + \varepsilon_{n,i} > V_{n,j} + \varepsilon_{n,j}$ or $\varepsilon_{n,j} - \varepsilon_{n,i} < V_{n,i} - V_{n,i}$ and thus the estimated probability will be $P_{ni} = \Pr\left(V_{n,i} + \varepsilon_{n,i} > V_{n,j} + \varepsilon_{n,j}\right) or \Pr(\varepsilon_{n,j} - \varepsilon_{n,i} < V_{n,i} - V_{n,j})$. Hence, only the difference in utility matters and not the absolute value of U_i and U_j. This implies that the only factors that can be estimated are those that capture differences across alternatives (Train, 2009). The latter is an important statement that should be accounted during the specification of the models, namely if the model will entail only attributes of the alternatives and/or *alternative specific constants* (ASCs), and/or attributes of individuals such as socio-demographic variables. ASCs capture the average effect of the disregarded factors, and are interpreted the same way as the constant in a regression model. Attributes of the alternatives vary across alternatives, and differences in utility are thus apparent. However, socio-demographic variables are constant across alternatives, implying that such variables have to be specified in a way that will initiate differences in utility (Train, 2009).

The RUM can be used as the baseline tool for modeling individual preferences for public goods such as ES conservation and improvements. In this dissertation, individuals correspond to all interested actors, namely citizens (in Studies I and II) and landowners (in Studies II, III and IV). The preferences may ultimately represent the citizen demand for and landowner provision of certain ES. The vector of z factors relates to individual-specific or questionnaire-specific characteristics, such as

[6] To analyze panel data, the RUM framework needs to be adjusted so as to reflect the choice situation or choice set t. Then the choice probability will be given by the formula $P_{njt} = \frac{e^{V_{njt}}}{\sum e^{V_{njt}}}$ and the error term is IID over $n, j,$ and t. Each set of choices by the decision maker is considered as a separate observation.

socio-demographic variables, attitudes, and subjective perceptions relevant to the choice of ES conservation. The vector of *x* factors refers to the attributes of ES or attributes of management plans or programs for ES conservation.

3.3 Econometric models

3.3.1 Binary models

Logit and probit models

In binary choice models, the decision maker faces two alternatives, i.e. $j = 1,2$, and the dependent variable *y* which represents these two choices can take only two values, 0 and 1. A logit model is derived by the RUM general framework under the assumption that the unobserved utility follows a specific distribution, i.e. that ε_{nj} is an *independently, identically distributed (IID) extreme value* (also called a Gumbel type I extreme value), and thus the errors are independent of each other. The independence implies that the unobserved part of the utility for one alternative is unrelated to the unobserved part of the utility of another alternative. This implication is actually derived from the *independence from irrelevant alternatives* (IIA) property of choice models, which is in line with utility maximization (Train, 2009).

Econometrically, the RUM is described by a *latent regression model*, where the dependent variable y^* is a latent variable that represents the strength of the individual's preference for *i* relative to *j* (Greene, 2009). Hence, y* can be expressed as

$$y^* = \beta_0 + x\beta + \varepsilon$$

which satisfies all the classical linear model assumptions (Wooldridge 2000: 530-533). Latent variable y* may represent the difference in utility levels from two different choices, and as such, if $y^* > 0$ then $y = 1$, and if $y^* \leq 0$ then $y = 0$. All the observed factors are labeled *x*. The random element ε is assumed to be independent with zero mean and unit variance.

The probability that $y_n = 1$ is given by the relationship:

$P_n(y_n = 1|x_n) = G(\beta_0 + x_n\beta)$.

For a logit model, the function G is the cumulative density function of the logistic function calculated as $G(c) = \frac{e^c}{1+e^c} = \Lambda(c)$ and lies between zero and one. The logit model is derived by assuming that the ratio of the odds, i.e. $\log\left(\frac{P_n}{1-P_n}\right)$, equals $x_n\beta$. Solving for P_n, we get the probability $P_n = \frac{\exp(x_n\beta)}{1+\exp(x_n\beta)}$ (Davidson and Mackinnon, 2009: 454–456).

The probit model is very similar to the logit model[7]. In probit binary response models, G is the cumulative standard normal distribution function estimated by $G(z) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{z} exp\left(-\frac{1}{2}z^2\right)dz$ which is easily evaluated numerically as its first derivative is the standard normal density function. Then, the probability that $y_n = 1$ will be $P_n = G(x_n\beta)$.

The most common way to estimate binary response models is through the *maximum likelihood estimation* (MLE) method. MLE maximizes the log-likelihood function for observations $i = 1, \dots n$:

$logL = \sum_{y_i=1}^{n} logP(y_i = 1|x_i) + \sum_{y_i=0}^{n} logP(y_i = 0|x_i)$.

[7] The two models usually provide similar predicted probabilities. However, logit estimates tend to be larger in absolute value than probit ones, due to variance differences in the distribution of the models (Davidson and Mackinnon, 2009: 457). In addition, the probit model relaxes the assumptions of the logit model, namely the IIA property, and it can deal with taste variation (Train, 2009).

MLE works by obtaining the estimates of parameters β that maximize the total likelihood of observing the outcomes as reported.

Rare events logit model

The statistical problem of rare events occurs when a binary dependent variable is characterized by much fewer ones (events of occurrence) than zeros (non-events). A logit model would perform adequately for the (relatively) large number of zeros, estimating the density of x for the group of zeros, while for the few ones, the estimation of density would be poor and systematically downward biased. In other words, the logit model would lead to biased estimates and to an underestimated probability of rare events. In the presence of rare event data, King and Zeng (2001[a,b]) suggest replacing a logit model with a rare events logit (Relogit).

Relogit has been widely used by researchers in studies of international relationships, e.g. wars, revolutions and massive economic depressions, but also in other disciplines in order to explain and predict rare events. Relogit performs the same logit command but with an estimator that gives a lower mean square error for coefficients, probabilities and other quantities of interest. It corrects for the bias that exists in logit coefficient estimates, providing bias corrected estimates[8], $\tilde{\beta} = \hat{\beta} - bias(\hat{\beta})$ and improved methods of computing probabilities accounting for the bias, corrected estimates, as well as the uncertainty in $\tilde{\beta}$ (King and Zeng, 2001[a,b]). Both the unbiased logit coefficients and the improved method of computing probabilities lead to an increase in the estimated probability, and the effect is larger in the case of rare events or small samples, or both. Relogit applies stochastic stimulation to compute quantities of interest, such as risk probabilities, relative risk probabilities, and first differences[9], which are corrected of rare events bias.

3.3.2 Multinomial and conditional logit models

Multinomial logit models (MNL) correspond to the behavioral models that deal with more than two alternatives in an unordered response. The expected utilities are modeled in terms of individual characteristics $V_{nj} = \gamma_j z_n'$, and thus individual specific characteristics are the same for all choices. McFadden (1974) suggested a model that would allow the expected utilities to depend on the attributes of choices/alternatives rather than individual characteristics, and thus $V_{nj} = x_j'\beta$, where x_j' now represents the choice attributes. The model is called a conditional logit (CL) model and it is similar to MNL or log-linear models, but the factors of decision are in terms of choice attributes. Like logit models[10], CL models satisfy the IIA property. They assume that respondents will show a similar preference structure. In a CL model, it is often useful to include an ASC to capture all observed and unobserved attributes that describe a reference alternative and are identical across individuals. The alternative that is usually considered as reference is the *status quo* alternative, and hence the ASC shows how utility deviates from the *status quo state* and the variation in preferences not explained by

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[8] For the expression used to estimate the bias in $\hat{\beta}$, see Appendix C in King and Zeng, (2001[b])

[9] The absolute probabilities refer to $\Pr(Y = 1|X = x)$, while relative risk probabilities refer to $\frac{\Pr(Y = 1|x = 1)}{\Pr(Y = 1|x = 0)}$. First difference is the change in probability as a function of a change in a covariate, i.e. $\Pr(Y = 1|x = 1) - \Pr(Y = 1|x = 0)$.

[10] The ratio of probabilities of any alternative solely depends on the explanatory factors of x_{nl} and x_{nj} and the associated parameters.

the attributes as independent variables. An exclusion of this term would lead to biased attribute parameter estimates (Morrison et al., 2002). Parameter estimates can be interpreted as the direction of influence of independent variables on the choice probability of alternatives, i.e. the probability of choosing an alternative other than the *status quo*. Their absolute magnitude has no meaning.

3.3.3 Modeling heterogeneity

Mixed logit models

Mixed logit models are considered more flexible models that can represent any RUM (McFadden and Train, 2000) if independent variables and the mixing distribution are appropriately selected. In case researchers wish to test or suspect heterogeneity in preferences, these models are more appropriate than the CL model. The model is called 'mixed' because the choice probabilities are the integral of standard logit probabilities over a density of parameters

$$P_{nj} = \int \frac{\exp(x_{nj}\beta')}{\sum_{j=0}^{J} \exp(x_{nj}\beta')} f(\beta) d\beta.$$

Coefficients β vary across respondents and follow a distribution with density $f(\beta)$[11]. The mixed logit probability of choosing alternative j is a weighted average of the logit formula at different values of β with the weights given by the density $f(\beta)$. The mixing distribution $f(\beta)$ can be discrete, implying that coefficients β take a finite set of distinct values, or $f(\beta)$ can be continuous, where β follows a normal, log-normal, uniform, triangular, gamma, or any other distribution. The former case is applied when there are no strong *a priori* assumptions regarding the source of heterogeneity, and the latter for the opposite case.

Random parameters logit with interactions

It is often the case that researchers strongly sense the heterogeneity and its possible sources. Certain spatial or socio-demographic or psychological factors can determine the preferences of respondents. If true, then a random parameters logit (RPL) with interactions is a suitable option (McFadden and Train, 2000; Train 1998). The model allows preference variation in terms of both unconditional taste (random heterogeneity) as well as individual characteristics (conditional heterogeneity). The RUM will now take the form:

$$U_{nj} = a + \sum_k \left[bx_{njk} + \delta_n x_{njk} \right] + \sum_m \gamma_m z_{nm} \cdot a + \varepsilon_{nj}$$

where α corresponds to a constant term that takes the value 1 if any alternative other than the *status quo* is selected, and 0 otherwise. The terms bx_{njk} and $\gamma_m z_{nm}$ represent the conditional heterogeneity that originates from attribute k of alternative j and from the individual-specific characteristic m, respectively. The later term can interact with α so as to reveal the sources of heterogeneity. On the other hand, the term $\delta_n x_{njk}$ represents the unconditional heterogeneity, which captures the random taste among individuals, the correlation over alternatives and the time or situation. RPL follows the properties of the mixed logit described above. The sum of parameters b and $\delta_n$can be substituted by one parameter β, which will vary randomly across respondents following a distribution with density$f(\beta)$. Simulation techniques are employed to estimate the parameters of the RPL model.

[11] In the standard logit, $f(\beta) = 1$ and β is fixed.

Latent class analysis model
With no strong *a priori* assumption about heterogeneity in preferences, a latent class analysis model (LCA) can appropriately approximate the RUM. The variance in preferences can be better explained at the segment level than at the individual level (Colombo et al., 2009), and coefficients β takes S possible values corresponding to S segments in the population, each of which pursues its own choice behavior. To allow for heterogeneity, the RUM has to be adjusted accordingly:
$U_{nj|s} = \beta_s x_{nj} + \varepsilon_{nj|s}$.
LCA divides individuals into behavioral groups, i.e. latent segments s, and hence utility functions vary between segments but are homogeneous within the segment. The deterministic part of utility can depend on attributes of the choices as well as on socio-economic and attitudinal characteristics of the individuals (Boxall and Adamowwicz, 2002), and the choice probability for respondent n to select alternative j, conditional on him/her belonging to segment s, is the following: $P_{nj|s} = \sum_{s=1}^{S} \left(\frac{exp(\gamma_s z_n)}{\sum_{s=1}^{S} exp(\gamma_s z_n)} \right) \cdot \left(\prod_t^T \frac{exp(\beta_s x_{nj})}{\sum_{j=1}^{J} exp(\beta_s x_{ni})} \right)$
where z (x) represents the individual-specific variables (the choice-specific variables), γ (β) the corresponding estimates and t the choice set of alternative j. Individual factors indirectly affect the choice probability by predicting the segment membership.

LCA is estimated by the MLE method, but in an itinerary process. Incomplete information on segment membership is replaced with expected values and MLE is performed as if these values are the right ones. The outcome updates the initial assumptions and MLE continuously until the log-likelihood function does not improve further. The assumption regarding the number of segments starts from $s = 1$ then $s = 2$, and so on. Since there is no rigorous way to select the optimal number of segments, several information criteria can be employed. Following literature suggestions (Colombo et al., 2009; Boxall and Adamowicz, 2002), Bayesian (BIC) and Akaike (AIC) information criteria follow the improvements in the log likelihood function as additional segments are added, correcting at the same time the model fit, which is affected by the increased number of observations and parameters. To reach a decision, the score of goodness of fit measures (i.e. log likelihood score and ρ^2) and the score of AIC and BIC have to be accounted for. The optimal number of segments would lead to the minimum AIC and BIC[12].

The model produces two outcomes: how choice attributes affect the choice probability and how individual attributes affect the segment membership. An ASC can also be included to capture the variation in preferences not explained by the choice attributes. Decision makers are allocated in M segments, while one segment's parameters are normalized to 0, acting as the reference level. For each segment, the attributes' coefficients indicate different preferences, thus revealing the presence of heterogeneity.

3.4 Using econometric models for welfare estimates

[12] Information criteria can provide guidance for model selection, but not necessarily clear-cut solutions. In this case, bootstrapping methods can facilitate model selection by showing statistically significant improvements in the model fit when segments are added.

The parameters that may be obtained from the abovementioned multinomial models (MNL, CL, LCA or RPL) can serve as important inputs in welfare estimations, i.e. what monetary value individuals place on a certain ES, or what change occurs in an individuals' income given a hypothetical change in the provision of the ES. Welfare estimations are crucial in policy assessment, as they can justify whether a policy measure or initiative is efficient in economic terms. *Economic efficiency* holds when the sum of benefits to those who gain from the policy exceeds the sum of the costs to those who lose. For ES or public goods in general, benefits and costs are derived from individual preferences, provided that these preferences are "comprehensive, stable and coherent" (Bateman et al., 2002). The benefits are measures in WTP terms, and the cost in WTA terms. CBA applies the efficiency criterion to evaluate and prioritize policies.

Assuming a linear utility index and a cost factor included as an attribute of the available choices, the marginal[13] welfare measure estimates, such as marginal WTP or marginal WTA, can be provided by the ratio of the coefficient for any attribute β_i to the negative of the coefficient for the cost attribute β_p, *ceteris paribus* (Louviere et al., 2000):

$$MWTP\ or\ MWTA = -\left(\frac{\beta_i}{\beta_p}\right).$$

This is also called the implicit price of attribute i. To calculate confidence intervals, several measures are commonly used such as bootstrapping techniques, the Krinky-Robb procedure, or Delta methods (appropriate in case the sample is sufficiently large).

To evaluate hypothetical policy scenarios, the welfare change can be estimated by employing the compensating surplus measure, which refers to the amount of money a decision maker is willing to pay so that after the change he/she can be as well off as before the change. CS can be derived from the formula below (e.g. Colombo et al., 2009; Kosenius 2010):

$$E(WTP) = -\frac{1}{\beta_p}\left(\sum \beta_i (x_i^1 - x_i^0)\right)$$

where $\beta_i x_i^0$ and $\beta_i x_i^1$ represent the indirect utility before (initial state) and after (alternative state) the change, respectively.

4. Data and econometric specifications

4.1 Data sets and questionnaire design

Studies I and II

Study I analyzed residents' preferences for hypothetical changes in a typical agricultural landscape setting and investigated the presence of heterogeneity in preferences. Study II examined the application of a Payment for Ecosystem Services (PES) instrument, in which both buyers and sellers were accounted for. Both studies aimed to conclude whether such a scheme could be feasible and to stress the challenges that actors need to consider during the design phase.

The data were collected via a mail survey in March 2008. The survey was addressed to all households in the postal areas that surround the Nurmijärvi study area. The selected area is located in southern

[13] The change is initiated by a policy proposal and it refers to the change in the utility level from the initial state to the alternative state, at the margin.

Finland, approximately 37 km from the center of Helsinki. The case study area represents the typical southern Finnish agricultural landscape, which is oriented towards intensive grain production.

The sample comprised 2172 households, including both residents and landowners. A reminder postcard was sent a week after the date when questionnaires were mailed so as to facilitate high response rate (Dillman, 1978). Finally, questionnaires were mailed again to all non-responding households, yielding a total of 630 responses, which corresponds to a 29% response rate. Out of the 630 responses, 109 were from landowners. The sample was found to be representative of the Finnish population, except for the proportion of highly educated people and those with a higher income level, for which the sample share was larger than the population share.

A locally based PES scheme was established under a hypothetical scenario and was presented to the respondents. This scenario concerned a voluntary trade scheme where residents would pay for landscape improvements and to avoid any further landscape deterioration. Landowners would participate if the compensation sufficiently covered their expenses in providing landscape services. The trade was planned for a 10-year period, during which participants would be required to pay for these services. Following the presentation of this scenario, a CE was employed to introduce the local landscape attributes that would comprise the elements of the trade. The attributes were selected based on former references from Finland, public discussions, stakeholders' suggestions, and on policy relevance[14]. Six attributes were selected, namely the proportion of uncultivated land, the number of plant species per 100 ha, the presence of grazing animals, the management and condition of water protection zones and the state of the production buildings. All attributes were specified on three levels, of which the first level corresponded to the reference level and the rest to landscape improvements. Each choice set was associated with a hypothetical payment, which ranged from €0 (status quo) to €200 within 11 discrete levels. The range of the payment was tested through a pilot survey addressed to 100 individuals. Both residents and landowners were regarded as purchasers of landscape services, and they were asked to choose their preferred management option in six different choice sets. Since the number of choice attributes as well as their levels resulted in a large number of options, a balanced overlap design procedure was applied to reduce to the number of choice versions into 40. All landscape attributes presented in the choice sets were illustrated by using photographs (Pouta and Salmiovirta, 2008).

The remaining part of the questionnaire concerned attitudinal factors (e.g. attitudes towards a landscape value trade scheme or towards agri-environmental issues), factors that measure the use of the landscape, as well as factors to evaluate the sentimental attachment to and appreciation of the landscape area. For the socio-demographic profile of respondents, a set of questions eliciting gender, age, ownership, occupation, household size, income and residency was presented at the end of the questionnaire. For a detailed description of the variables and their measurement, the reader may refer to the following sources: Grammatikopoulou et al., 2012[b] and 2013.

Study III

Study III analyzed the factors affecting the adoption of water conservation measures and explored whether landowners who operate in areas where water quality is at risk they are more likely to adopt the measures.

[14] The choice experiment was focused on attributes that were not part of the Finnish AES, and hence they were not assured *per se*.

The sample of landowners, both actively engaged in farming as well as passive landowners, was selected from the register of the Finnish Tax Administration based on records for 2004. In order to gain a representative sample from all regions in Finland, sampling clusters were formed based on criteria such as the field area and the regional distribution of ownership. Next, a survey was conducted in late autumn of 2006 and questionnaires were mailed to 6080 landowners. Focus groups discussions and a pilot survey were preceded this survey in order to provide inputs for the questionnaire design. The survey yielded 2684 responses, which corresponded to a response rate of 44%. Due to item non-responses, 1838 observations were finally available for the analysis. Of the final sample, 37% represented active farmers whereas 63% represented passive owners. Based on additional information that was available from the register of agricultural and income taxation, the sample adequately represented the population of farmland owners in Finland.

A question regarding the adoption of water conservation measures was part of the mail survey in Study III. The question had two versions, one of which was addressed to active and the other to passive owners. Active farmers were presented with a list of measures for which farmers had received environmental support in 2005. The measures were related to water eutrophication aiming to reduce erosion and nutrient run off (for detailed information, see Grammatikopoulou et al., 2015). Passive owners were presented with a question in a more generic form and were asked whether they had adopted any voluntary measure to improve water quality. Background information on socio-demographic, attitudinal and farm-related factors was part of the analysis. Moreover, the survey data were supplemented with GIS data on water quality and soil characteristics. To obtain GIS variables, the geographical middle point of each farm was indicated with x,y coordinates and the water and soil measures were obtained for the nearest field to this middle point. Soil characteristics were represented by two soil types, peat and clay soils, which were respectively related to N leaching and erosion issues. The water quality index, which provides a general usability classification of water bodies (applied by the Finnish Environmental Institute), was used as the measure of water quality.

Study IV

Study IV explored the profile of participants in agri-environmental auctions (AEau$_s$) and aimed to incorporate all sets of factors that may have affected participation in a pilot auction, as well in future auctions.

The data were provided on the basis of a pilot auction project conducted in the municipality of Nurmijärvi, southern Finland, in 2010. In the pilot project, local farmers were asked to make bids when applying a given amount of gypsum (four tonnes per hectare) on land parcels of their choice. The bid entailed the compensation payment as well as parcel characteristics, such as the size, slope, proximity to surface water, and phosphorous status of the soil. The latter information was used to estimate the environmental benefits (i.e. the potential load of phosphorous to surface waters) that corresponded to each bid, and the bids were subsequently ranked according to the ratio between the benefits and compensation. After completion of the pilot project, a questionnaire was sent to 234 farmers, out of whom three were not reached. After a reminder and a second round of posting, 108 completed questionnaires were returned (47% response rate). The questionnaire had five parts, where respondents were asked in parts 1 to 4 to assess several statements related to agri-environmental issues, AEau$_s$, the pilot auction in the Nurmijärvi area, and future auctions. Part 5 concerned the farm and demographic characteristics of the respondents.

4.2 Model specifications

Study I

In Study I, respondents' choices were model by employing two econometric models: i) a CL model and ii) a LCA model. The CL model was used as the base model to provide a general idea of respondent's preferences for landscape improvements, whereas the LCA was used as a step further to also explore the presence of heterogeneity in respondent preferences. Both models were estimated by including the same attributes, as well as an ASC. For the final choice of individual characteristics that would be estimated as covariates to explain heterogeneity in LCA, prior tests were performed to examine their effect on segment membership. Welfare measures, i.e. WTP estimates for each attribute, as well as compensating surplus estimates related to three hypothetical scenarios of interest were also provided. The models were estimated with the Latent GOLD Choice 4.5 software package.

Study II

In Study II, the presence of heterogeneity was examined by employing an RPL model. An RPL with no interactions was tested, which indicated that only half of the respondents were positive towards landscape improvements. Based on this, an RPL model with interaction was then performed in two versions, by assuming that the heterogeneity originated from i) the land ownership profile and ii) other socio-demographic variables such as gender, occupation, residency, age, education, income, place of childhood, use of area, and environmental attitudes. For the first version, the land ownership profile was interacted with all attributes, while for the second version, the set of socio-demographic variables was only interacted with the ASC. The WTP for discrete improvements in attributes was estimated. A comparison of costs and benefits for improving the attributes that positively affect respondent's utility and at a statistically significant level was also reported. Costs referred to draft calculations of the aggregate cost of services, while benefits were calculated by using the WTP estimates. Both versions of the RPL model were estimated using Limdep 9.0 Nlogit 4.0. Aside from the expenses attribute, all other parameters were specified to follow a normal distribution, while distribution simulations were based on 1000 draws.

Study III

In Study III, a probit model was used to examine the probability of adopting water conservation measures. The dependent variable was coded as a binary variable taking the value of 1 if adoption was positive and 0 otherwise. For the selection of the explanatory variables, the recommendations originating from the meta-analysis of Knowler and Bradshaw (2007) were followed. To incorporate landowner attitudes with reference to values attached to farming and land ownership, four sets of statements were constructed that were measured on a five-point Likert rating scale. The structure of these four sets was tested by employing factor analysis, with principal component analysis and varimax rotation, as well as reliability analysis. To avoid multicollinearity, the factor loadings for each set were used rather than a summative or mean variable for each set of statements. Then, two probit models were constructed for each group of owners, i.e. active and passive landowners. The models were identical for all factors except that in model 1 the region variables were excluded, whereas in model 2 the GIS data were excluded. This was due to the presence of a significant correlation between the region and GIS data. Both coefficient estimates and marginal effects were reported. The parameters of all models were estimated using the NLogit5 software package.

Study IV

In Study IV, a stepwise analytical approach was followed so as to determine the final models. I decided to follow this approach due to the lack of sufficient knowledge from past studies regarding the factors that can potentially explain participation in voluntary auction schemes. Moreover, due to the small sample size and the low variation in dependent variable, the set of independent variables had to be limited. Any missing values in explanatory factors were replaced by random numbers, assuming that the original variables followed a normal distribution. Logit models were employed to estimate the probability of participation in the pilot auction scheme, as well as in future auctions. Following the stepwise approach, four models were tested: the null model, in which farm and farmer characteristics formed the explanatory factors, and three alternative models, in which attitudinal factors were also incorporated in the list of explanatory factors[15]. The three alternative models corresponded to three distinctive sets of attitudinal factors, i.e. attitudes towards AESs, attitudes towards the auction mechanism, and finally, attitudes towards the pilot (already completed) auction scheme. The correlation between some of the factors was found significantly high. Therefore, the set of factors that described each attitudinal category had to be individually included in the model. Only significant variables formed the null model, which constituted the baseline for forming the alternative models 1 to 3. Then, a final model was formed by selecting the variables that were found significant at the 1% significance level or higher in alternative models, also accounting for any multicollinearity problems. To argue for any improvement in the model fit between the null model, the alternative models and final model, I used several goodness-of-fit measures such pseudo R^2, Akaike and Bayesian information criteria, as well as the likelihood ratio (LR). Finally, a Relogit model was formed to correct the coefficient estimates of the final model. First difference estimates were also provided so as to describe the probability change generated when explanatory variables changed from minimum to maximum values.

Table 2: A summary of the data and methods

Studies	Objective and related ES	Data			Methods	
		Number of cases	*Target population*	*Case study area*	*Econometric models*	*Welfare estimates*
Study I	Citizens' preferences for cultural services provided by the agricultural landscape	630	Residents and landowners	Southern Finland; Nurmijärvi area	• Conditional logit • Latent Class Analysis	• WTP • Compensating surplus
Study II	The demand for and supply of cultural services provided by the agricultural landscape	630	Residents and landowners	Southern Finland; Nurmijärvi area	• Random parameters logit • Random parameters with interactions	• WTP • Cost–benefit considerations

[15] Based on findings from previous studies, I categorized the statement questions into four categories. Then, for each category, I performed a factor analysis with principal component analysis and varimax rotation so as to construct uncorrelated factors. Additionally, the revealed factors were tested by applying reliability analysis. Only factors that had a Cronbach's alpha coefficient above 0.60 were retained in the set of explanatory variables of the logit models.

Study III	Landowner’s willingness to participate in measures that support soil retention and water purification	1838	Landowners	All Finnish regions	Binary probit	-
Study IV	Farmers’ willingness to participate in measures to mitigate the eutrophication of water bodies and nutrient run-off	108	Farmers	Southern Finland; Nurmijärvi area	• Binary logit • Rare events logit	-

5. Summaries of the articles

5.1 Study I: Heterogeneous preferences for agricultural landscape improvements in southern Finland

A CE was applied to evaluate people’s preferences for a landscape planning scheme that aims to provide certain landscape attributes in a typical agricultural landscape in southern Finland. CL and LCA models revealed which attributes positively affect people’s utility, while an LCA model indicated the existence of heterogeneity in preferences.

According to the CL model, only the presence of grazing animals and the renovation of production buildings increased the utility of respondents at statistically significant level. The ASC estimate suggested that utility will decrease away from the status quo, while several variables were non-significant. These findings indicate that preferences may be heterogeneous and alternative models have to be tested. Allowing for heterogeneity, the LCA model revealed that the levels of certain landscape attributes, i.e. a decrease in the proportion of cultivated land, an increase in crop variety, the management of water buffer zones and the demolition of production buildings, are determined by heterogeneous preferences.

The LCA model with covariates concluded in four segments of homogenous preferences. Three out of the four segments were in favor of landscape improvements, while one segment, representing 21.07% of respondents, opposed them. Segment 1 respondents formed the majority and determined their choices by the presence of grazing animals and the renovation of production buildings. Segment 2 respondents displayed a positive preference for an improvement in almost any attribute. Segment 3 respondents were the most skeptical and their choices were mainly based on the cost of the option. Finally, segment 4 respondents mostly preferred a high proportion of uncultivated land, in contrast to all other segments. The segments were identified by socio-demographic as well as attitudinal variables.

Regarding the welfare significance of landscape attributes, the LCA model revealed that the separable landscape elements such as the presence of grazing horses and cattle as well as the renovation of production buildings are the most highly valued, with a marginal WTP estimated at

€82.52 and €35.78 per person, respectively. The LCA model predicted a positive marginal WTP of ASC, implying that respondents are willing to pay for improvements in attributes not included in the choice sets. Welfare changes were defined within three scenarios of interest and WTP ranged from €147.57 to €227.52 for various levels of attributes assigned to each landscape scenario. Segment 1, i.e. the majority of respondents, doubled its average welfare as scenarios were improved, whereas segment 3 respondents comprised the 'losers' for any policy change.

The demand needs to be considered with care, particularly when the examined ES is not a simple one-dimensional public good such as landscape amenities. The observed negative and positive welfare changes illustrate the importance of accounting for public preferences in landscape planning and exploring (if any) the profile of citizens' segments with heterogeneous preferences. The findings imply that simple focal points such as the presence of animals as a landscape attraction may increase society's welfare. The findings support the current trend for recreational riding activities and the formation of 'horse zones' around cities. Organic husbandry, where animals are kept outside according to related regulation, is also advocated by the results.

5.2 Study II: A locally designed payment scheme for agricultural landscape services

The study examined the feasibility of a PES scheme that is locally implemented in order to ensure the supply of agricultural landscape attributes demanded by the local citizens. Summary statistics provide strong *a priori* assumptions regarding the sources of heterogeneity in people's preference, and an RPL model with interactions was thus employed. Descriptive statistics were applied to reveal the willingness of landowners to participate in a PES scheme.

The descriptive analysis regarding the seller's side (supply) revealed that 42.9% of landowners were negative towards participating in the PES scheme. The positive or indecisive landowners were willing to improve attributes that are less important for local citizens, such as increasing the proportion of cultivated land. For most of landscape attribute improvements, landowners demand compensation that is equal to or higher than the anticipated expenses. Insecurity and the instability of agricultural income, as well as the contribution of agriculture to the environment, are the most important reasons behind landowner's reluctance to participate in the scheme.

An RPL model interacting with the land ownership profile revealed that citizens are positive towards a shift from the status quo to landscape management alternatives, as implied by the ASC. The dispersion of the ASC parameter as well as of most of the attributes, represented by the standard deviation, was statistically significant, implying the presence of heterogeneity. Landowners were found to specifically prefer a landscape with a higher proportion of cultivated fields. Allowing for interactions between the ASC and socio-demographic and attitudinal factors, the sources of heterogeneity extended further than the land ownership profile. Residents of the Röykkä region in southern Finland, environmentally conscious citizens and frequent users of the landscape were more willing to improve the landscape status from its current level, while professionals in agriculture or forestry showed less preference for any improvement.

Only the attributes that positively affected the respondent's utility at a statistically significant level were included in the management scenario for the PES scheme. According to the second version of RPL model, these attributes were the presence of grazing animals, water buffer zones and the renovation of buildings. Welfare estimates were calculated on a 10-year basis in line with the duration of the PES scheme. The aggregate welfare estimates indicated that the benefits outweigh by far the implementation costs of improving the most significant attributes. Transaction costs were excluded and the foregone income was anticipated to be negligible. The difference between the benefits and the costs implies that there is a margin able to cover the landowner's requirement for compensation that exceeds the cost.

Given the high incentives in stated preferences studies to free ride, the RPL model predictions combined with a statement of the resident's obligation to pay indicated that the proportion of free riders was roughly 46%, and the proportion of contributors thus reached 54%. The latter percentage is higher than the estimated rate of participation (i.e. 40%) necessary for a PES scheme to be feasible and is in line with previous reports (Haan and Kooreman, 2002; Fishbacher et al., 2001). For the overall evaluation of the PES scheme, the results suggest that people lack trust in relation to practical issues such as the scheme's realization and its contribution to enhancing the agricultural landscape.

By investigating both the demand and supply, the study concluded that the implementation of a PES scheme incorporating the most significant attributes could be feasible. Nonetheless, the scheme's performance is mainly challenged by the disposition of landowners.

Transaction costs can be sustained at a low level if the scheme is spatially narrowed. This finding, on top of the small number of beneficiaries and the substantial welfare benefits, provides some evidence that free riding will not hamper the scheme's progress. The valuation analysis provided a price framework that could be utilized by the trading bodies and help them to decide whether a bid offer from landowners can be accepted.

5.3 Study III: Exploring the determinants for adopting water conservation measures. What is the tendency of landowners when the resource is already at risk?

The study estimated the probability of adopting water conservation measures and investigated the factors that explain the variation in adoption among a sample of active and passive landowners.

The probit model addressed to active landowners revealed that conservation behavior is positively affected when the water quality of the closest to farm water bodies is degraded. On the other hand, farmers who operate farms in which soil type is associated with erosion and nutrient leaching risks are less keen to adopt conservation measures. The model also revealed that conservation behavior is spatially diversified, with owners in the southern and eastern parts of Finland being more reluctant to adopt conservation measures as compared to owners in the western parts of the country. Larger farms were found more likely to adopt such measures, since they are more flexible given the wider heterogeneity in the plot-level productivity, with lower opportunity costs and a greater comparative advantage over small-scale farmers. Moreover, the probability of adopting measures was positively related to variables such 'education', 'high income', 'use of contractors', 'decision making solely by the farmer', 'planned production orientation' and 'importance of information sources'. In contrast, the variables of 'profitability' and 'residency on the farm' were negatively associated with the likelihood of adoption. Among the attitudinal factors, only those related to nature and recreation had significant and positive parameters. In summary, farmer and financial characteristics displayed higher marginal effects on the probability of adoption than the water quality status or soil type.

The model addressed to passive landowners yielded a different picture. Passive owners were found less keen on voluntarily adopting any measure when water quality is at risk. Moreover, owners from the south, east and north of Finland were positive towards conservation measures, in contrast to owners in the western regions. The variables 'off-farm income' as well as the 'size of the farm' were significant and positive determinants. A high level of education was negatively associated with the likelihood of adoption, whereas young owners were more receptive towards conservation. The importance of 'recreational values' and 'farm production values' had a positive and significant influence. In summary, the water quality indicator, off-farm income levels and attitudinal factors displayed the largest marginal effects on the probability of adoption.

All in all, the models did not clearly support the initial expectation that owners would be naturally motivated to adopt measures in areas where the environmental state has deteriorated, even though past studies have demonstrated this natural tendency (Zbinden and Lee, 2005; Toma and Mathijs, 2007; Amsalu and Graaff, 2007). The study concluded that AEPs have to incorporate targeted measures that are spatially tailored, in which landowners are compensated according to the environmental benefits they produce, even if the costs are substantial.

5.4 Study IV: Willingness of farmers to participate in agri-environmental auctions in Finland

This study investigated the participation of farmers in an auction scheme from the perspectives of both a real choice (participation in the pilot auction project) and a stated choice (participation in future auctions). Due to the small sample size, the Relogit model provided more reasonable predictions of the probability of past and future participation than the logit model. According to the Relogit model predictions, the probability of having participated in the pilot auction project was estimated at 6.9 percentage units, while for future auctions the corresponding probability was 14.4%. The findings indicate a low willingness to participate in $AEau_s$. Among the farmer and farm characteristics, the amount of owned arable land positively affected the decision of the farmers to participate in the pilot auction. Farmers who had attended training were more likely to participate in future auctions, whereas full-time and older farmers were less keen in participating. Novel and possibly complex schemes such as auction schemes attract farmers who have the capacity to better understand the information (Vanslembrouck et al., 2002; Raymond and Brown, 2011) concerning the mechanism and its process.

Surprisingly, spatial variables, i.e. proximity to water bodies, did not explain much of the variation of the participation variable for either the pilot auction or future auctions case. The findings stress the need for emphasizing spatial conditions in auction rules during the planning phase and clarifying the associated credits. In this way, $AEau_s$ would attract more farmers who can provide greater environmental benefits and avoid spatial uniformity in participation.

The models indicated that past experience and attitudinal factors have a strong influence on participation, but the former has a minor effect compared to the latter. Active past participation positively determined the future tendency to participate, which is in line with *a priori* expectations. The past participation factor entails important aspects such as confidentiality, risk aversion and uncertainty. These aspects need to be accounted for during the planning phase of the mechanism. In addition, past participation entails the risk of adverse selection and high information rents by attracting participants who 'have already learnt the game', and thus the scheme loses its cost-effectiveness merit.

The performance of the model was found to considerably improve when attitudinal factors were incorporated into the model, stressing the significant power that these factors have in explaining farmer behavior. The change in the predicted probability indicated that attitudes concerning the novelty feature and complexity of the auction mechanism may significantly affect the probability of farmers participating in the pilot auction. According to the Relogit first difference estimates, farmers who more highly appreciated the novelty element were 26% more likely to have been participants in the pilot auction, while farmers who were discouraged by the mechanism's complexity were 20% less likely to have participated. Likewise, for future participation, the attitudes towards environmental protection and income–time issues were found to considerably affect the probability of participation. First difference estimates revealed that the likelihood of participation was 16% greater among farmers with a high rating for environmental protection, whereas for those concerned about the financial outcome of the auction, the likelihood dropped by 13%.

6. Conclusions and discussion

The present dissertation highlights the key policy design and implementation issues for MBSs and TBSs to successfully provide ES. The dissertation presents solutions for the provision of cultural services from landscape amenities and regulating services of soil retention and water purification, through the implementation of a Payment for Ecosystem services (PES) scheme and an agri-environmental auction scheme (AEau) that represent the MBS and TBS accordingly.

Implications of a PES scheme for landscape amenities

The key challenges found in the studies of this dissertation in designing a PES scheme are the presence of heterogeneity and free riding incentives from the demand side, and the presence of hesitancy and strategic thinking from the supply side.

The presence of heterogeneity in demand among regions may complicate the formulation of the content of the policy. A common scheme where one trading body bears the responsibility to organize, establish, administer, and monitor the scheme would demand more time, consequently increasing the transaction costs. To reduce free riding incentives, the PES scheme is proposed to be spatially narrowed.

The challenging mainly comes from the seller's side, since landowners are a heterogeneous group but mostly negative towards participating in a PES. They are both providers and users of ES, and there are cases where owners appreciate less the non-market value of ES due to the high income dependency on the markets. These cases mainly refer to owners who are actively engaged in the agri-forestry sector. In addition, landowners may require less compensation for providing attributes (e.g. for keeping more fields cultivated) that are already subsidized through AEP measures. This raises doubts about the 'additionality' criteria of the PES scheme, and supplementary measures are suggested so as to avoid double compensation. The PES scheme should also account for strategic thinking, since landowners show greater willingness to improve attributes that they would improve regardless of the scheme.

The bottom line is that a user-financed PES scheme tailored to the local demand may supplement the traditional nationwide AEP measures. Keeping the scheme at a local level is crucial for the scheme's progress so as to enforce social incentives, to communicate the scheme easily and in a less costly way, to allow easy access to key decisions and to reduce uncertainty concerning the contribution of fellow citizens. In this way, obstacles such as transaction costs and free riding incentives can be avoided. Heterogeneity in preferences in both demand and supply will also be limited if the scheme is locally based. The results regarding the WTP for certain attributes provide a baseline for determining the targeting criteria of the trade. The market price will be determined by the demand and supply at the time of implementation.

Implications for an AEau scheme for water conservation services

The studies of this dissertation suggest that the traditional AEP will ultimately be forced to incorporate and/or occasionally be replaced by spatially tailored TBSs such as $AEau_s$, since uniform action-based schemes lead to inefficient policy performance. Such a need will also emerge given the unclear outcomes regarding the spontaneous tendency among landowners to adopt conservation measures in areas where the state of resources is poor.

Spatial diversification of conservation behavior is related to the state of agricultural production and the income loss that farmers bear when applying conservation measures. For example, farm production is intensive in the south, while farming activities are of a smaller scale in eastern areas. Western regions are oriented towards animal production, where conservation is more imperative due to manure issues. Passive owners in the western region are more reluctant to adopt any measure, possibly due to the lower importance of water bodies for recreation in the west. These outcomes provide guidelines for planning spatially tailored TBS: more incentives in the south for active farmers and information campaigns for passive owners in the west.

$AEau_s$ are a good example of TBSs, but the participation rate in $AEau_s$ is low, and thus at the moment, the AEP cannot be solely based on auctions. To raise participation, $AEau_s$ should be kept simple but without losing the novelty feature, which forms a significant motivating factor for farmers. Past experience positively affects future participation in $AEau_s$, although it may result in an efficiency trade-off, i.e. a higher participation rate but lower budget efficiency due to the effect of learning. Nevertheless, the effect of past participation is minor compared to that of attitudes, and this strong effect is in line with a large number of previous studies (e.g. Mäntymaa et al., 2009; van Putten et al., 2011; Reimer et al., 2012).

Moreover, $AEau_s$ should be better targeted at those landowners who are more receptive to conservation measures and at innovative policy interventions such as auctions. Acknowledging the profile of landowners is of considerable policy relevance.

The effect of attitudes may have a practical value *per se* considering that attitudes are affected by the way policy decisions are promoted and communicated. Nonetheless, this conclusion should be interpreted with care, as it partly contradicts the argument that environmentalism/stewardship incentives are not always strong enough to motivate farmer behavior, and even though farmers care about environmental benefits, they need financial incentives to act. For policy design, explicit attitudes, i.e. the attitudes that are directly related to TBS, are more informative than general ones.

Passive landowners hold considerable decision-making power, and their participation should be accounted for during policy design. To raise awareness, extension services can be targeted at this group of owners. Considering the strong attitudinal values that passive owners demonstrate, lease contracts can be enhanced by a commitment to ES conservation. Lengthening the lease-contract period may also raise synergies between active and passive owners towards conservation goals.

The research conducted in all case studies refers to the AEP of the 2000–2006 and 2007–2013 program periods. At this point, it is worth mentioning that the AEP has been reformed in the framework of the new Rural Development Plan of 2014–2020. Under this new structure, the AEP is anticipated to address some of the aforementioned issues, as well as some of the weak points in the AEP of the previous programming periods. Some parcel-specific measures will even be targeted at certain regions, such as the southern parts of Finland, where the status of the soil and surface water is considerably degraded. Moreover, parcel-specific measures are estimated to yield higher payments than farm-level ones, since they are considered more effective. This is in line with the criticism against the AEP and in line with suggestions of better incentives for farmers who produce greater environmental benefits.

Contribution of the research to the empirical literature

Studies I and II succeed in enhancing the literature by providing empirical results regarding the preferences for landscape attributes in a typical agricultural landscape in northeastern Europe. Although the findings are local, they may apply in a broader context. Moreover, the results can be extended beyond the provision of landscape amenities considering that the diversification of agriculture, with initiatives such as recreational activities around cities, could also facilitate water conservation and waste management.

The ex-ante valuation of a PES scheme by using stated preference data, as described in Study II, contributes significantly to previous case studies, which usually comprise ex-post valuation of PES schemes and reviews of implementation (e.g. Hackl et al., 2007; Dobbs and Pretty, 2008). The overall suggestions regarding PES design, derived from the study's findings, will assist policy planning in the future. The latter is in line with the general tendency of the AEP that emerges from a shift from action-based support to benefit-based support, where farmers and landowners are compensated for providing environmental goods.

The findings of Studies III and IV significantly improve research knowledge on the pro-environmental behavior as well as the profile of adopters, for both active and passive landowners. The findings are important records for the assessment of the AEP in Finland, as water conservation is still an unresolved issue. By combining survey data with national-level GIS data, study III managed to enhance landowner studies with valuable information regarding the relationship between conservation and the environmental state. Typically, data sets in landowner studies are survey based, including only landowners' perceptions of environmental quality.

Study IV enlightens the decision-making process in relation to its very early stage: the stage of participation depicting the profile of auction participants and their future tendency. The findings represent the first knowledge input of $AEau_s$ in Finland, as the data were derived from an auction experiment that was implemented in Finland for the first time.

Recommendations for future research

The basic structure of a PES scheme also entails a governance system that consists of the rule-setting process, the monitoring, control and evaluation process, as well as the definition of criteria (conditionality) (in Bruno et al., 2011, pp. 245). The survey in Study II included a part that aimed to approach all three elements by asking citizens to evaluate the PES scheme through a set of statements. Future studies need to further elaborate issues in the governance part, such as the role of a trading body, the targeting criteria, the payment mechanism, which should account for spatial heterogeneity, and the measures for monitoring. These matters most likely have local solutions that can be investigated in real world experiments.

The CL, LCA, and RPL models in Studies I and II reported statistically significant ASCs. This indicates the presence of unobserved effects. Future studies that aim to explore landscape preferences in the Finnish context will have to incorporate more landscape attributes in the choice experiment (or any other relevant method).

Study III provided vague evidence regarding the natural motivation of landowners to adopt measures in areas where the environmental condition is poor. This may reflect the type of data used or a lack of awareness from the landowners' side regarding the condition of resources, or unfamiliarity from the farmers' side in accounting for factors other than income in their response towards participation in conservation measures. Further research is needed to focus on the formation of environmental perceptions and, through motivation, to yield data that would reflect people's awareness of the state of resources.

In all case studies, attitudes are incorporated as explanatory factors in the choice models. Nonetheless, there is an ongoing discussion in the literature concerning whether this is the right practice. Responses to attitudinal questions should not be treated as direct measures, but rather as a function of underlying attitudes. Moreover, there is a risk of endogeneity bias, since attitudes may be correlated with other unobserved factors that are part of the error term (Hess and Becharry-Borg, 2012; Hoyos et al., 2015). These concerns should be taken into consideration in the model specifications, as they may be reflected in the model outcomes and, in turn, in the elicited recommendations. Future studies may further investigate this issue by employing more adequate models, such as hybrid latent class models (Hoyos et al., 2015) or joint latent class models (Meldrum, 2015).

AEau$_s$ are attracting increasing interest for being more effective in providing environmental goods, but at the same time they are associated with a number of risks, such as a low participation rate (due to insecure payments and limited access to information), ineffectiveness in monitoring, and high administration and transaction costs (Ollikainen et al., 2008). Current research knowledge is limited, as AEau$_s$ and TBSs in general are in a trial or experimental state. Further research input is needed to determine farmers' acceptance of and response to auction initiatives prior to introducing any major change in the AEP framework (Burton and Schwarz, 2013). Citizen perceptions, which would represent the demand side, could also be examined and would provide information on the acceptable levels of public expenditure allocated to auctions.

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