Ecological Complexity 7 (2010) 368–377

Contents lists available at ScienceDirect

Ecological Complexity

journal homepage: www.elsevier.com/locate/ecocom

Spatial modelling of agrarian subsidy payments as an input for evaluating changes of ecosystem services

Hermann Klug *, Petra Jenewein

Centre for Geoinformatics (Z_GIS), University of Salzburg, Schillerstr. 30, Building 15, 3rd Floor, 5020 Salzburg, Austria

ARTICLE INFO

Article history:
Received 11 February 2009
Received in revised form 9 November 2009
Accepted 3 December 2009
Available online 15 January 2010

Keywords:
Ecosystem services
Environmental accounting
Environmental economics
GIS
Spatial planning
Rural Development Policies
Agriculture

ABSTRACT

The only constant in landscapes is change. Among other influences, such as climate change, these changes are driven by political decisions affecting ecosystem services. The overall research objective is to define how the European Union's political strategies implemented through Rural Development Programmes and the Common Agricultural Policy might influence or change ecosystem goods and services in the future. This paper aims at outlining the research framework and especially focuses on spatially explicit modelling the distribution of subsidy cash flows on farm and parcel level. Experiments with changing political strategies and incentive payments were carried out in the Mondsee catchment (Austria) using Geographic Information Systems (GIS). The results were visualised and show the dominant (inter-)national and regional funding programmes of this area. They further display the likely effects of changing political strategies on the monetary value of certain parcels and the overall farm–parcel balance. The validation of an aggregated set of funding measures reveals 15% deviation between the model framework and real subsidy payments. This approach is suitable for both (a) estimating the impact of changed funding strategies at EU level and (b) supporting farmers in identifying the best economic income sources on parcel and farm level. Embedded in the overall research objective the results constitute the basis for opening a discussion on how ecosystem services might change with political intervention strategies in rural areas and resulting landscape changes in the future.

1. Introduction

Due to stronger accountability requirements and increasing budget constraints, the EU's Rural Development Policy needs to understand the impacts of Rural Development Measures implemented in EU 27 (2007–2013) in a spatially explicit way so that limited funds can be targeted more effectively (performance and capacity) and efficiently (measure of success). To meet these objectives, adequate concepts, models, and a spatial toolset – based on Spatial Econometrics – is needed to assess the impact, effectiveness, and efficiency of measures. The EU is at the same time facing new challenges such as climate change and water scarcity that will greatly affect the environment. These challenges need to be addressed now and especially in the period after 2013 at a high level of disaggregation.

On September 19, 2005, the EU Agriculture Council adopted strategic guidelines for Rural Development (RD) for the period 2007–2013 (Council Regulation (EC) No. 1698/2005). These guidelines outlined a range of measures that need to be implemented by national Rural Development Programmes in each Member State. Since the reform of the Common Agricultural Policy (CAP) in 2003 and the political agreement by EU's agriculture ministers on the CAP's "Health Check" (http://tinyurl.com/56cezx), Rural Development is playing an increasingly important role in helping rural areas meet challenges of the future. In the early period of the European Union, 80% of the EU's budget was used to finance the agricultural sector. Since then, European and national funding for sustainable land management is subject to a decline from 47% in the year 2001 (43.3 billion EUR total budget) to presently 38%. Due to the agricultural policy agreement adopted in October 2002 in Brussels, this trend is predicted to continue down to 32% in the year 2013 (Auswärtiges Amt, 2006).

We argue that this forecasted decline of funding resources might put substantial pressure on landscapes. The pressure is, among other factors, caused by land abandonment, bush encroachment and afforestation (especially in the case study area mentioned below). But also the markets pressure on e.g. the food and energy sector influence changing labour efforts spent on farming practices. These changes also have consequences for ecosystem goods and services e.g. associated with landscape scenery affecting recreation activities.

* Corresponding author. Tel.: +43 662 8044 5261; fax: +43 662 8044 5260.
E-mail address: hermann.klug@sbg.ac.at (H. Klug).

1476-945X/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecocom.2009.12.005

To maintain relevant services and to develop a landscape of tomorrow, it is necessary to create and establish an inventory of spatially explicit environmental goods and services (yellow, green and blue services) present in a landscape (see Table 3 and Fig. 3). This inventory postulates a comprehensive understanding of landscape complexity and should define the products intangible and important for the prosperity and well-being of the local population. It should also identify necessary ecosystem processes and functions in order to provide specific ecosystem service products. Despite the fact that it is a very important and ambitious task, so far there is neither a meta-disciplinary nor a disciplinary consensus on those processes mandatory to keep certain services alive. Furthermore, different interest groups and key players might be confronted with contradictory use of certain services.

The Common Monitoring and Evaluation Framework (CMEF, http://tinyurl.com/6c7ofn) has been established in the framework of the Rural Development Regulation (1698/2005) to create a system that allows to evaluate the contribution of Rural Development Programmes of the Member States to the overall programme's objectives and EU priorities. Since all 94 national and regional operational programmes are now fully operational, CMEF allows consistent EU wide programme assessments through quantitative (indicators) and qualitative evaluation on a continuous basis (monitoring and ongoing evaluation). These programmes are defined as 88 national or regional Rural Development Programmes, 2 National Frameworks, and 4 Programmes on National Rural Development Network – http://tinyurl.com/8td92j) approved by Brussels. The strategy was to create a system which is strongly oriented towards flexibility of programming and based on strategic analysis at national and regional level to maximize value. The programming exercise works in a decentralised way, in a framework of partnership between the EU and the Member States and the regions concerned. This allows the design of Rural Development Programmes that are tailor made to the situation of a specific area or country.

Further development of natural resources mandates the support of agricultural businesses by adequate payments in order to manage and maintain those ecosystem services demanded by society in the future. After all, landscapes comprise an economic value, which needs to be captured besides food production. We frame the hypothesis that the value of ecosystem services we use is much higher than the subsidy payments disbursed for their maintenance. Unfortunately we cannot answer this question here but instead establish a framework within which it is possible to analyse and model past and present subsidy cash flows and forecast future developments based on specific assumptions for scenario building.

In response to this complex challenge, the overall research objective is to present a methodology developed for spatially explicit describing, modelling and classifying the impact of political decisions on ecosystem goods and services in the future using scenario techniques for visualisation. The authors propose a methodology combining Ernst Neef's School of Landscape ecological theory and land surveying techniques to capture the natural states, conditions and potentials of landscapes. Process-oriented classification methodologies and concepts for ecosystem analysis and assessment provide information on distinguishable functions working in landscapes (Bastian and Steinhardt, 2002). The units derived from landscape analysis capture the multifunctional and multidimensional space of ecosystem services. Combined with theories and concepts from Economy and Social Science the value of functions for society can be determined and clustered at parcel level for the purpose of regional planning, landscape planning, nature conservation and environmental protection. These land

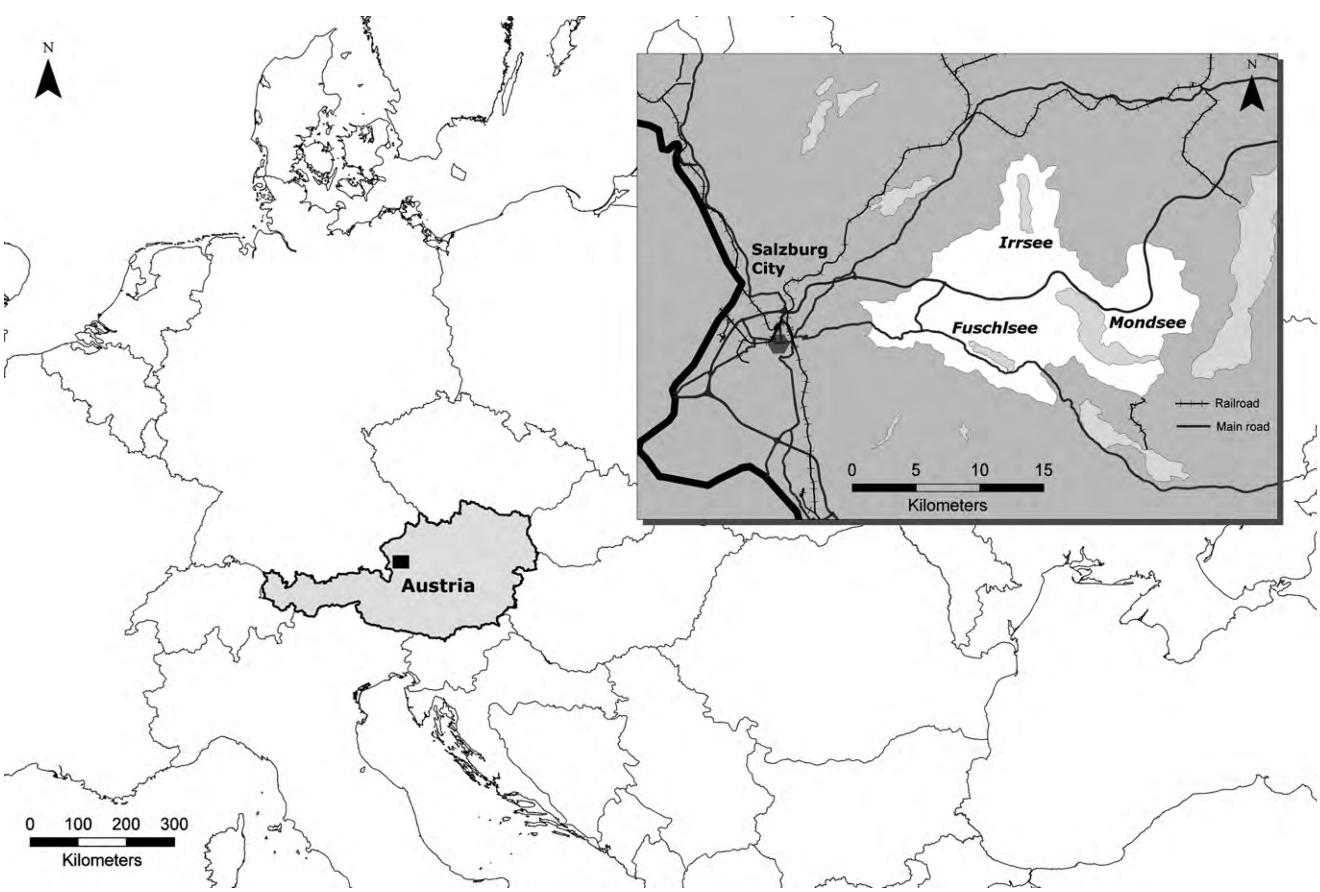

Fig. 1.

use/land cover units are acquired from satellite imageries or aerial photographs using remote sensing techniques and change detection methods (Klug et al., 2007).

Economic-political guidance and control of financial resources is strongly recommended if we want to handle the limited resources that are available for society and environment to our best knowledge. This requires modelling of subsidies based on farm and parcel level. The results should reveal spatially explicit regional disparities based on changed funding structures. Based on new concepts and methodologies, this decision support tool predicts the likely consequences of future regulation and political decisions on the landscape of the Mondsee catchment study area. The three main objectives of this contribution are firstly, conceptualising a methodology that is able to capture scenarios of likely consequences of political interventions in regard to the agrarian funding system, secondly, investigating the amount of subsidies employed by farmers and its share in the farmers' annual balance sheet, and finally to investigate likely consequences of policy interventions on ecosystem services.

2. Methods

This chapter outlines the overall concept and the materials used to facilitate the ground rent approach. The first section introduces a general approach of ecosystem goods and services (chapter 2.1) which results in an inventory of spatially explicit ecosystem services (chapter 2.2). The inventory aims at understanding the claimed natural resources and functions as a basis for a general discussion of the benefit of such a tool for society. With the inventory at hand we face the problem of environmental accounting in terms of money (chapter 2.3). This problem will only be discussed briefly, because it is not the focal point of the paper. However, the spatial units taken for service evaluation are necessary elements for the approach submitted here (chapter 2.4). Farmers receive subsidies from (inter-)national and regional funding bodies based on parcel level if they comply with the framework of Cross Compliance (VO [EG] Nr. 1782/2003 and VO [EG] Nr. 796/2004). Thus, the knowledge of available funding programmes triggers the cash flow of subsidies. Changing subsidy payments in turn might modify agricultural management practices which are ultimately effecting the provision of ecosystem services (chapter 2.6). The Mondsee catchment served as a case study area to model this proposed approach (chapter 2.7).

2.1. The concept of ecosystem services

Landscapes consist of a multitude of ecosystems. These ecosystems are based on certain environmental structures reflecting imminent landscape processes. The processes shaping landscape structures are inherently complex and interrelated with certain ecosystem components (soil, water, relief, geology, flora and fauna) as well as the human impact on land use patterns.

Rural areas cover about 91% of the EU's land area and are the home for about 50% of its population (Parish, 2008). Since about half of the rural land is farmed, agriculture clearly has an enormous influence on the state of the natural environment and its capacity to generate ecosystem services that ultimately support the well-being of people (cf. MA, 2005; Rounsevell et al., 2006). The reform of CAP in 2003 explicitly recognised the importance of these issues, and argued that "increasingly [policy should be] aimed at heading off the risks of environmental degradation while encouraging farmers to continue to play a positive role in the maintenance of the countryside and the environment by targeted Rural Development Measures" (http://tinyurl.com/5llqfv). Identifying the services currently provided by rural areas and the impact on these services due to policy changes is therefore a major challenge. The European Union is therefore strongly committed to improving its natural environment (http://tinyurl.com/66cbyj, p. 11). In order to design appropriate initiatives, and to measure their success, methodologies and tools must be developed to assess the success of outcomes.

While taking advantage of natural resources for human benefit, intervention is increasing with demand. As human populations grow rapidly, so do the resource demands (Tilman et al., 2002). Ecosystem services are, however, not invulnerable and infinitely available! Since society has realised that ecosystem services are not only threatened and limited, but also that pressure is rising, an evaluation of trade-offs between immediate and long-term societal demands is urgently needed. A landscape inventory system is required to capture these services, to estimate the relevance and sustainable use of this resource and to value the benefits of these resources in terms of money.

2.2. Inventory of spatially explicit ecosystem services

Provision of ecosystem services and their maintenance by farmers are not captured in commercial markets or politics nor are they adequately quantified. So far they have been given little attention in political decision-making. Only when services are overexploited or stop working, re-active actions are denoted to turn back to previous conditions or to eliminate consequences (e.g. flooding due to decreasing retention areas). It is argued that the neglect of valuing ecosystem services has consequences which ought to be considered today rather than tomorrow.

As mentioned in the introduction, ecosystem goods and services can be unitized into three service categories: green, blue, and yellow services (see Fig. 3). All three services are strongly interacting and partly superimposing. Capturing these services and the benefits for society enables one to identify those products that are intangible and important for a specific landscape. Impacts of anthropogenic use and abuse for these three service categories are becoming ever more apparent; air and water quality and quantity are compromised, biodiversity is decreasing and partly gene pools from vanished red list species decrease, deforestation and land amelioration is eliminating water retention possibilities and flood control around human settlements and pests and diseases such as the cow disease are extending beyond their historical boundaries. Further guidance on general types of ecosystem services is given by the Millennium Ecosystem Assessment Report (MA, 2005, p. 165) and de Groot et al. (2002).

2.3. Accounting spatially explicit ecosystem services

It is widely acknowledged that the natural environment provides a wide range of goods and services that underpin human well-being (MA, 2005; Costanza et al., 1997; Naidoo et al., 2008). Despite the real progress being made in relation to the spatial characterisation of the dynamics of ecosystem services, knowledge of where change is occurring is not sufficient in terms of decision-making. The context in which change occurs also needs to be investigated. Regional authorities or landscape stakeholders need to capture local services demanded by society; thus, they need to be based on local culture, values and constraints (Tilman et al., 2002). Public participation approaches identifying the requirements, needs, and values of resources are a first starting point (Klug, 2007a). Understanding patterns of supply and demand for ecosystem services, both across sectors and across spatial and temporal scales, is of major importance for future sustainable developments. Insights on the potential of agricultural systems to supply ecosystem service coupled with knowledge about the need to support rural development might be used to target payment schemes for ecosystem services, with the level of payments adjusted in relation to understandings about the level of service output that is required. In addition, the significance of change in rural areas triggered by various drivers could be assessed according to the significance they have for different places, given their various economic, social, and environmental characteristics. The valuation of ecosystem services in particular needs such an approach since their economic value is associated with personal values and hence the respective stake considered. The main challenge of assigning economic values to natural units is prompting transdisciplinary shifts in the recognition and management of the environmental, social, economic and political responsibility and multidisciplinary opportunities of resources use.

The complexity of ecosystems poses a tough challenge for scientists as they try to understand how spatio-temporal relationships are interconnected with processes and functions (de Groot, 2006). Understanding ecosystem services therefore requires a strong foundation in landscape ecology, which describes the underlying principles and interactions of environment and people in a transdisciplinary way. Valuing these ecosystem goods and services relates to Environmental Accounting (see Farber et al., 2002). Environmental Accounting aims at measuring the contribution of natural capital to societal benefits and to document recent, present and future costs resulting from the overuse or damage to services provided by nature. The Intergovernmental Panel for Climate Change (IPCC) is for instance reporting effects of climate regulation due to an increase of CO_2 in the atmosphere (IPCC, 2007). While contributions to account ecosystem services on a global level (Costanza et al., 1997) are necessary and strongly supported by the authors of this article, practised methodologies reveal conflicts at larger spatio-temporal scales:

- Ecosystem services (ES) work at a certain spatial and temporal scale. Interpreting ecological information collected at a certain reference scale cannot necessarily be transferred to another scale.
- ES do not carry the same value in the world but are changing locally due to their fundamental anthropocentric character. Demands on ecosystem services spatially vary among countries, regions as well as social and ethical groups.
- ES retain a disparity between actual and perceived values. This relates possibly to peoples' limited acknowledgment of the interrelatedness of societies and the natural environment.
- ES depend on the local properties of land use/land cover, soils, water distribution, geological underground, climate/air, and relief.
- The services might change periodically or in a certain time period (seasonal changes).
- The preconditions to provide certain ecosystem services strongly depend on the natural and cultural background of a region.

Despite the value of the six methods of Environmental Accounting used by Farber et al. (2002) (Avoided Cost, Replacement Cost, Factor Income, Travel Cost, Hedonic Pricing, and Contingent Valuation), we did not apply them as our research question was: "How much is presently paid in subsidies to farmers and how these income sources might influence the sustainable provision of demanded ecosystem goods and services?" This leads to the question of spatial units available for calculating present payments in order to maintain ES.

2.4. The spatial and temporal units

A Land Accountancy System (LAS) specifically attempts to interpret natural properties and their changes in terms of processes that transform one service to another. This is enabling the assessment of subsequent changes. These changes are based on spatial locations. Spatially explicit units need to be combined with economic valuation practices mentioned in the previous chapter. As an emerging field, *spatial econometrics* is combining GI-Science with Economics including findings from Environmental and Social Sciences. Valuation in this respect refers to the process of giving a monetary value to a particular unit that is representing one or more ecosystem goods and services (Farber et al., 2002, p. 376).

When trying to apply monetary values to certain landscape units we need to determine how these units should be framed. They can either be based on locations determined by the natural or by administrative boundaries. The latter can be equivalent to farm parcels playing a crucial role in EU agrarian funding schemes. According to the Common Agricultural Policy these units need to be captured in an Integrated Administration Control System (IACS) if EU subsidies want to be claimed. In Austria, the Agrar Market Austria (AMA) is providing the IACS service including a huge amount of spatially explicit information (e.g. land use, crop rotation system, intensity of use, subsidy measures taken for each field). These administrative units refer to the farm owner and those people who are shaping and embossing the landscape with their business. In this respect, farmers can be entitled the *ecosystem service providers* (*ESP*s) receiving money from the EU and national funding bodies to maintain the services provided.

Even though administrative boundaries are easier to use due to availability of statistics, natural boundaries are more important for assessing a landscape's capacity in terms of ecosystem services. To capture locally or regionally available ecosystem services, an inventory should be based on the analysis of e.g. land use/land cover, soil, water and climate properties, and other parameters such as from the socio-economic sector. A list of ES available in a certain region might be ranked according to priority and temporal availability.

While the payments of subsidies are considered on a yearly basis, the temporal units for ecosystem service supply might be different for each ES. Seasonal shifts in ecosystem service supply and its priority in relation to other services might be rather the rule than the exception. Thus, the importance of ecosystem services and their local priority for environment and society might alter in time due to

- changed management practices,
- (inner)-annual land use/land cover changes (crop rotation, intercropping), and
- change of natural conditions.

One example: buffer stripes separating agricultural fields from surface water bodies are most active within the vegetation period. At this time, the capacity of riverside plants has the maximum potential to take up nutrients and prevent surface water bodies from eutrophication. At the same time, agricultural business is most intensive and thus the nutrient retention and buffer function strongly required. In turn, in winter time, no agricultural business and thus no nutrient transfer to agricultural fields occur while the riparian forests are also not able to take up nutrients.

Ecosystem services might also shift due to (inner)-annual land use/land cover changes. For example, crop rotation or intercropping is changing local conditions and with them processes which might affect local as well as neighbouring functions. For instance an annual change from meadow to tillage bordering to surface water bodies (without considering buffer stripes) is likely to increase phosphorus emissions from terrestrial to aquatic water bodies due to higher erosion loads. Thus, the blue services are risking a higher nutrient pollution. As another example, land use changes might affect service provisions. Pastures used in the beginning of the vegetation period might be changed to parking zones used for local open air music events (Frequency Festival, http://tinyurl.com/ofshfw). Thus food production priority decreases in favour of societal entertainment.

Since the impact of changed subsidy payments on ecosystem services are considered on different spatial units and possibly also spatial and temporal scales, methodologies need to consider the most appropriate combination of both different scales and units. Since ecosystem services can only be directly measured in few cases, landscape change might be used as a proxy to estimate changes of ecosystem service functions.

2.5. Spatial decision support

The main driver of applied Geoinformatics in the field of environmental economics is the effort to inform decision-makers of present versus future costs and about the benefits of certain spatial resources. This involves

- defining the ecosystem services relevant for a region,
- translating scientific knowledge from several natural and social science disciplines, and
- organising the knowledge into economic values of comparable spatial units.

Understanding the dynamics of political decisions and their ecological and economic effects relative to the ecosystem services is essential when assisting political decision makers. As such conceived, the basic notion of value that guides political decision is inherently anthropocentric, or instrumental. To the decision maker, "value" is equivalent with the contribution of politics to the goal "satisfaction". While this value is related to the use of a specific item (maize crop) or object (parcel), the actual determination of a value price requires some objective measure if one should be able to estimate the degree, to which the thing or object improves income benefits and services for society. In a finite world of available financial resources, politics is interested in economic and environmental forecasts and strategies of incentive implementation. While economists have developed an extensive theory of how people behave in the presence of political constraints and incentives (Varian 1992), GIS can help to spatially explicit model this behaviour using scenario techniques. The working hypothesis in our case study is that farmers make decisions in order to optimise satisfaction. Satisfaction is referring to maximizing income and/or reducing work load. This optimisation process always takes place in the presence of certain constraints, such as income of the farm, time resources available, local resource supply and many others. In this respect, optimization yields a deterministic set of possible decisions relevant for most real-world situations. This hypothesis is reflecting the fact that when constraints (subsidies, incentives, regulations) change, so do decisions. A deterministic set of decisions enables the modelling approach to reflect and respond to changes in a predictable fashion. It allows forecasting certain political strategies and to intervene in the European agricultural funding system in order to manage sustainable natural resources.

A set of relevant criteria is important for this spatially explicit approach: fair distribution of resources among EU Member States and regions as well as an efficient and effective allocation of available resources (Daly, 1992).

Considering the requirements for decision support by stakeholders and politicians, we apply a ground rent model on farm and parcel level helping to balance the

- costs allocated for certain regions,
- for the annual farm balance, and
- single parcels of a farm.

This model framework has been applied to the case study area of the Mondsee catchment and compared to implications on ecosystem services in changing conditions.

2.6. Policy implications on ecosystem services

With respect to the Mondsee catchment we outline possible policy implications on ecosystem services relevant for this region. We demonstrate the subsequent process chain to explain how ecosystem services might change due to certain political strategies:

- political interventions (strategy changes using incentives, taxes or regulations as facilitator),
- proposed/forecasted change of subsidy payments,
- expected landscape change, and
- resulting change of ecosystem services.

2.7. The Mondsee case study area

The catchment area of lake Mondsee is about 30 km northeast of the city of Salzburg, Austria, and has an area of 248 km^2 (Fig. 1). The majority of the study area lies in the Alpine foreland and it is politically divided by the Austrian provinces "Upper Austria" in the East and "Salzburg" in the West. The area is characterized by its hilly appearance; only the south of the study area is dominated by the northern edge of the limestone Alps (Klug, 2007b). The catchment is small structured by meadows and pastures and some smaller remaining areas of arable land.

Of the 414 farmers (mainly cattle farms) more than half (232) are working on a small farm scale of 10–20 ha (Asamer and Klug, 2008). According to the data collected by Statistics Austria (www.statistik.at) the years 1981–1991 show a trend in decreasing labour force (yellow services) in the primary sector (approx. −30%) causing a trend from full time to part time farming practices (Oberösterreichische Landesregierung, 2004). In the years 2002 and 2003 the water pollution control noted an increase of phosphorus loads to the Mondsee (blue services) causing the water quality decreasing due to eutrophication (Klug and Zeil, 2008). Finally, green services have been estimated at risk due to changing land use/land cover also impacting tourism and local recreation activities.

Supporting decision makers with problem tailored modelling tools means to assist politicians in finding solutions for emerging problems. Solutions can be framework directives, obligations, subsidies or incentives, making a specific direction of development more attractive for people than another (Zeil et al., 2008). Besides environmental, social, and economic aspects, politics must be included in the process of valuing ecosystem services.

Since the farming system in Austria is not economically viable per se, key subsidy payments are necessary to retain agricultural practices. These payments are coupled with the Common Agricultural Policy (CAP), which has been implemented by the EU to guarantee a stable price system for producers and to preserve our rural heritage and ecosystem services. The CAP is based on the Cross Compliance where both regulations (VO (EG) Nr. 1782/2003 and VO (EG) Nr. 796/2004) are mandatory in order to be eligible to receive subsidy payments since the beginning of January 1, 2005. The company Agrar Market Austria (AMA) is legally obliged to promote agricultural marketing and thereby coordinates the funding payments in Austria. AMA employs an Integrated Administration

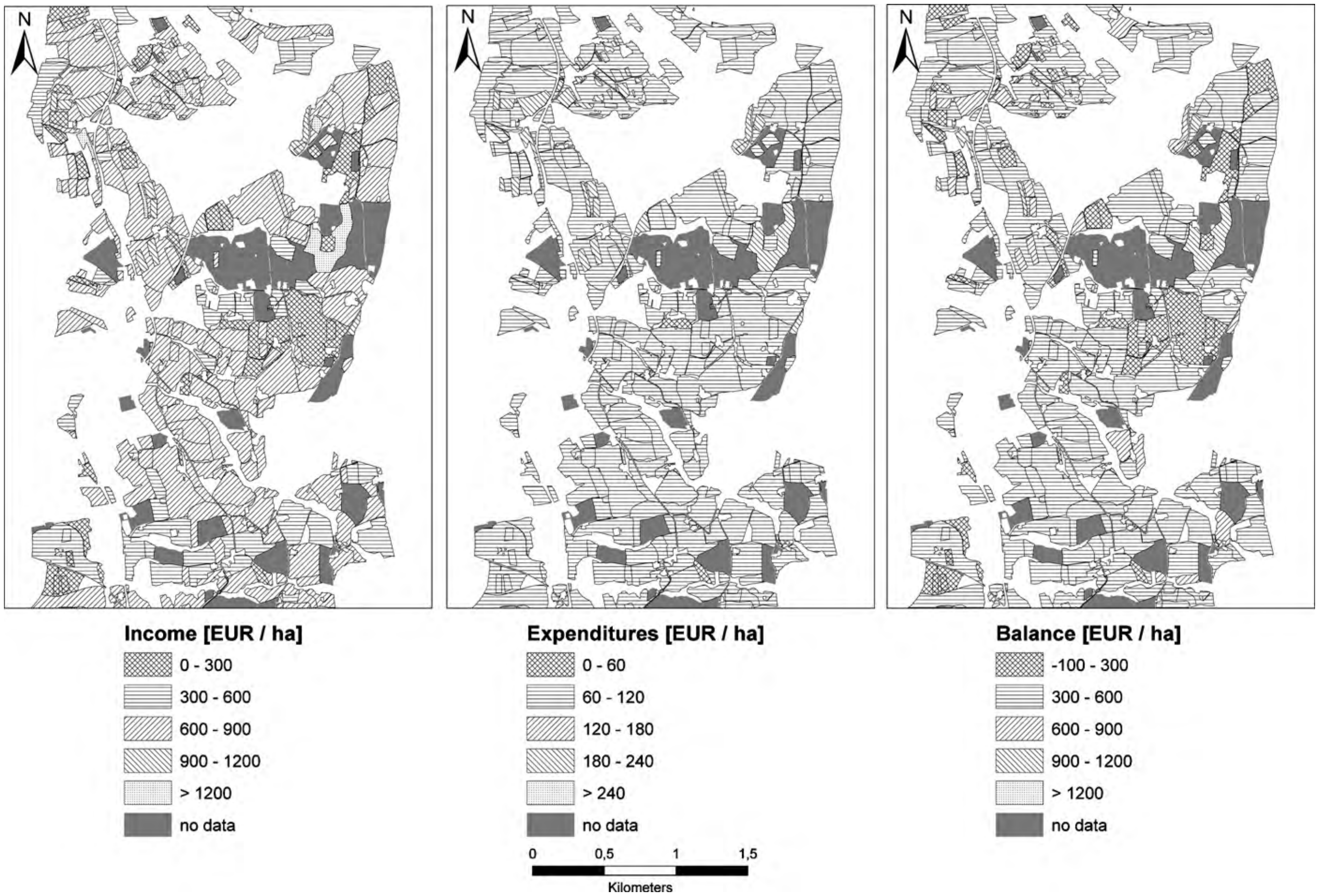

Fig. 2.

Control System (IACS) to register the subsidy payments based on the farmers' parcel and farm level. This spatially explicit inventory serves as a validation dataset for modelling.

The developed model is founded on collected information on all subsidy programmes of international, national and regionalised agreements which can be employed by farmers in the Mondsee catchment. Here, the national Austrian Agri-Environmental Programme (ÖPUL) is of significant importance to the farmers. We complemented this database by the farmers' real-life experiences for e.g. fuel, pesticides and nutrient costs or yield gained per hectare to capture their income and expenditures.

The ground rent approach employed after Von Thünen (1826) is based on the theory that spatial context and present place conditions matter for the net income of farmers. The model tries to systematize the economic principles of location based factors such as income and expenditures and maps them spatially explicit with Eq. (1) (see Schroers, 2006).

$$LR = ((y \times (pf + iv) + sv) - (sc + nc + pc + lc + pc + mc + tc + rc)) \quad (1)$$

LR: land rent; y: yield; pf: production fee; iv: improvement value; sv: subventions; sc: seed costs; nc: nutrient costs; pc: pesticide costs; lc: labour costs; pc: production costs; mc: machine costs; tc: transport costs; rc: rental costs.

Together with the previously mentioned database on funding programmes we developed a scenario for the year 2005 at parcel and farm level to assess the economic balance. We used ESRI's ArcGIS 9 with the ModelBuilder and Python scripts to semi-operate the model framework. In this framework we coupled the spatial explicit dataset from IACS with the developed funding database. In a first step, we modelled income (e.g. subsidies, yield) and expenditures (e.g. fuel, work labour, seeds) at farm and single parcel level. In a second step, we compared the modelled farm balances with real payments farmers received from AMA for validation. In a third step we employed a possible short term scenario to get an idea what might happen in the near and mid future. The scenario is based on a statement of the Austrian ministry of the Environment. The ministry argues for a strong reduction in the subsidy payment to maintain an open cultural landscape (OFFENKUL, Table 1). Effects on possible landscape changes caused by the exchanged agricultural funding bodies are assessed on the basis of the Rural Development Programme from 2007 to 2013 and the draft of the following period 2013–2019.

Table 1
Used programme measures in the Mondsee catchment.

Measures	Participation [%]
Baseline funding (GRUND)	100.00
Renunciation of silage (VERSIL)	77.29
Renunciation of yield increasing measures in grassland areas (VBG)	76.33
Maintenance of slopes (OFFENKUL)	65.46
Maintenance of valuable areas (WERTV)	31.88
Organic farming (BIO)	17.63
Salzburg regional project ground water protection and maintenance of grassland areas (REGSALZ)	10.63
Renunciation of yield increasing measures in arable areas (VBA)	8.21
Maintenance of orchards (ERHSTREU)	8.21
Others	40.82

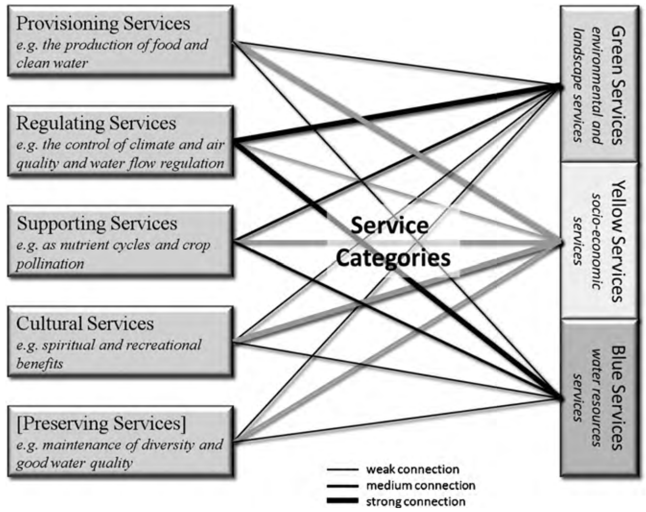

Fig. 3.

3. Results

The result of this ground rent approach is a general assessment system adapted to the regional, natural, cultural, political and economic conditions of the given case study area in the province of Salzburg and Upper Austria, Austria. As a first result, the planning procedure is shown to be a useful tool to enhance communication, scenario development, and planning of potential land use developments. Especially the analysis of subsidy programmes and their frequentation by farmers give insights into present shares of funding compared to the overall income. Furthermore, likely changing subsidy programmes causing spatially explicit changes give decision makers indicators of rural disparities, which might contribute to the change of ecosystem services.

Table 2
Comparison of model results and real payments from AMA in %.

Measures	AMA [%]	Model [%]	Variance [%]
GRUND	17.05	11.11	34.81
VBG	32.64	32.64	0.00
VERSIL	47.04	37.67	19.92
OFFENKUL	3.27	3.36	-2.75
Total	100.00	84.79	15.21

3.1. Subsidy and funding programmes

The cataloguing and the analysis of funding programmes, their content and designations as well as the amount of subsidy payment per area are developed in a database (Klug, 2010). Table 1 shows that particularly programmes on grassland funding dominate the acquisition by farmers in this area.

3.2. Spatially explicit results to be used for decision support

The development of a semi-operational GI toolbox helped to model the net yield for each parcel and farm. Considering Eq. (1), income from agricultural yields and subsidies as well as expenditures (e.g. fuel costs, insurance, and seeds) could be established on a hectare basis. Referring to the balance information in Fig. 2 (showing a part of the Mondsee catchment) one can see that the dotted areas and horizontally crossed symbols mark the highest yield per parcel, whereas parcels in double crossed symbol have a negative or equal to zero balance.

3.3. Model validation

A comparison of the results of the ground rent model and the real payments farmers received from AMA is used for model validation (Table 2). Of the considered programme initiatives GRUND, VERSIL, VBG, and OFFENKUL an average level of 85%

Table 3
Process chain of changing ecosystem services.

Policy strategy	Subsidy change	Landscape change	Ecosystem service category	Ecosystem service change
Overall reduction of subsidy payments with special focus on the reduction of subsidy payments “maintaining an open cultural landscape”	Decrease of the ÖPUL subsidy OFFENKUL	Afforestation Bush encroachment	Green service	Affects are expected to appear on the landscape scenery, which is very important in the case study area. Landscape scenery might affect the tourism sector. People come to this area for vacation and for local recreation using the lakes in the catchment for swimming, diving, boating and others activities such as hiking and mountain biking.
Enhancing landscape structure through the implementation of buffer stripes	Special incentives for establishing buffer stripes on agricultural fields bordering to surface water bodies	Surplus of linear elements and green structures	Blue service	Linear elements would increase habitat suitability for certain species and, most important for the case study area, would prevent direct nutrient discharge to surface water bodies. Thus, biodiversity, nutrient retention and buffer function would increase, while space for food production would decrease.
Retaining agricultural practices and related jobs in the pre-alpine Lake District	No change of baseline funding	No landscape change foreseen Prevention of bush encroachment	Yellow service	Due to incentives to farmers the landscape and its ecosystem services should be maintained. Positive effects are foreseen in the maintenance of job positions rather than ongoing decrease of working places in agricultural business.

ÖPUL: Austrian Agri-Environmental Programme.
OFFENKUL: Subsidy programme provided by ÖPUL, “maintaining an open cultural landscape”.

correctness is reached while some measures reveal more or less variance between modelled output and real payments.

3.4. Envisioning the future

With a reduction of subsidy payments ''maintaining an open cultural landscape'' (OFFENKUL) as forecasted by the Austrian ministry, we demonstrated that the annual balance for some parcels in the case study area will definitely be negative (Fig. 2). The farmers' expenditures are higher than their income.

3.5. Impacts of rural politics on the provision of ecosystem services

The three main problems outlined when describing the Mondsee catchment (decrease of agricultural working places, land use change, and water pollution) have been the initial starting point for the *SeenLandWirtschaft* (Engl. LandLakeEconomy) project. This project was running in the study area from 2004 to 2008. We use these three focal problems to analyse the impact of potential policy intervention on ecosystem services and how they might change the underlying services (see Table 3).

Changing a policy strategy means to respect a certain ''value'' which is equivalent to the goal ''satisfaction''. The reduction of subsidy payments is in accordance with the goal to decrease the EU's agrarian budget to 32%. According to the Ministry of the Environment in Austria, one option would be to reduce the subsidy payments to maintain an open cultural landscape (OFFENKUL). As our model showed, some parcels in the case study area will have a negative balance. Thus, green services such as the maintenance of a high biodiversity in grassland areas might be reduced in favour of less species rich bush fields or even forests. Even though bushes and forests will probably have different and/or high biodiversity, afforestation his is especially a problem in forest dominated regions. Additionally, particularly those parcels affected by the reduction of subsidies might be most relevant for perceiving the landscape as open and well structured. Since landscape scenery is strongly interconnected with recreation, tourism might be affected. People recreating in this area are hiking, swimming and mountain biking and are more satisfied with an open rather than a ''closed''/forested landscape.

4. Discussion

4.1. Present and future problems with funding programmes

As shown in the introduction, many of the EU 27 rural areas face significant challenges due to different constraints. Thus, the EU and its Rural Development Programme continuously tries to adapt its content, delivery method, and financial support to make a tangible contribution to the achievement of economic growth and sustainable development goals in rural areas. In particular, the CAP's Health Check will directly respond to ''new'' issues and support the Commission's key objectives for future rural policy – supporting bioenergy, mitigating climate change, protecting biodiversity and managing water resources. Due to decreasing funds for agriculture and RD, we face challenges of implementing immediate response actions. Mariann Fischer Boel, member of the EC responsible for Agriculture and Rural Development Perspectives and the promotion of the CAP's Health Check, stated at a meeting of the EP Agricultural Committee/National Parliaments Brussels, November 3, 2008: ''Personally, I expect that the public will demand more targeting in the future. Our citizens want to see clear results for the money, which they pay into a policy out of their pockets. It is not always easy to make things so clear, of course. But that's what we must aim for in the run-up to the next Financial Perspectives, when we will have to justify an adequate budget for the CAP.'' (Fischer Boel, 2008).

Since it is clear that present agrarian funding mechanisms at international, national and regional scale cannot be maintained in the future, there is a strong need to find strategies out of the dilemma of financing agricultural practices. According to our present knowledge, far reaching changes – especially in remote areas – are expected. If we cannot cope with these changes or compensate the decreasing financial payments with other funding strategies, landscape change will – without doubt – happen on high income parcels as well as low income parcels. This trend is still in process as outlined by Heissenhuber (2003) who reported the abandonment of parcels due to non-profitable yields. Furthermore, Silber and Wyrtzens (2006) noted that since 1960 the forested area in Austria has increased by approx. 2700 km^2. On the other hand Tilman et al. (2002) for 2050 forecast a required doubling of food production to secure enough food for the constantly increasing world population.

4.2. Decision support tools for landscape planning

The ground rent model cannot solve the problem of decreasing funding bodies, but the toolbox can offer help to identify the main areas or regions at risk. It can be an instrument for stakeholders and decision makers to develop an action plan towards the maintenance of those areas. This model framework is able to run a monetary indicator system able to capture the basic characteristics of the spatially adapted distribution of financial resources applied to agricultural areas. It serves as a decision-making tool for policy makers. Policy makers are able to predict the consequences of reduced subsidies for certain areas and can assess whether the instruments used and the policies implemented for rural development have an efficient and effective impact on rural areas in Europe. Politicians also might develop regional tailor made funding schemes for certain areas of interest to cope with locally identified problems. Additionally, this model serves as a tool for farmers and the farm advisory service. Applying this model can supply farmers with information regarding land use strategies which are financially feasible. This paper contributes to the development of tools supporting policy makers and farm advisory services in the implementation of Strategic Guidelines for Rural Development Policies at EU level.

When envisioning the future of the Mondsee catchment and considering decreasing funding of OFFENKUL, farming of land is not profitable anymore. This might lead to abandonment of farming and ultimately the abandonment of land. This causes either a reduction of work labour in farming, forcing the farmers to take on a second job, surrender farming at all or to retire. Especially parcels in remote areas and barren land with partly steep slopes are at particular risk of losing their cultural landscape characteristics, which in turn has consequences for the tourism industry (scenery) and biodiversity. Additionally, provisioning services (food production for animal fodder or human resource) are subject of decline and pose important services in the Mondsee catchment at risk. However, other services such as the regulating services might be supported. Due to the non-farming of parcels close to surface water bodies, nutrient input might decrease and thus prevent the lakes in the Mondsee catchment from eutrophication (Klug, 2010). Additionally, the CO_2 balance of the case study area might increase in case bush encroachments will proceed towards a forest. Consequently, this might reduce biodiversity.

Altogether, the GIS approach presented here is a model based on assumptions. Modelling different scenarios (e.g. subsidy decrease or increase, farmers' behaviour) provides an understanding of the spatial representation of different phenomena, dependencies of farm incomes on functioning ecosystems, and the role of governmental subsidies added to market value. It has been shown that changes in current situations might have direct impacts on the ecosystem's capacity to produce various ecosystem services in the future. How these scenarios, especially those of farmers' behaviours, are valid representation of possible futures cannot be accurately estimated.

4.3. Connecting subsidy payments with ecosystem services

To show how different subsidy payments are possibly influencing ecosystem service supply, both ecosystem services and subsidies are combined in Table 3. This table demonstrates how certain policy changes might affect changes of ecosystem services relevant in the Mondsee catchment. A couple of challenges remain.

When trying to account the value of subsidy payments for ecosystem service maintenance we face the challenge of connecting two different units and scales. On the one hand, subsidy payments are based on large scale administrative units (parcel level), while ecosystem services work at smaller scales and natural units. The problem to be solved is: how much does the single parcel, comprising certain management action, contribute to the provision of certain ecosystem services? In parallel, we face the dilemma that ecosystem services might only be relevant at a certain time of the year or might change priority related to other ecosystem services working in parallel. Additionally, with one subsidy payment aiming at a certain management action in the landscape, more than one ecosystem services will be supported; so the benefit of a single instalment is manifold and to be considered when aiming at ecosystem service valuation. This would require a complex relational database showing

- certain funding programmes,
- the expected management actions,
- the direct and indirect impact of management actions on ecosystem services, and
- the ranking of ES in terms of supply priority for natural or social welfare.

Priorities of certain ecosystem services are culturally and thus locally dependent. Generalisation of service priorities are hard to achieve on national or even EU level. Thus, whether the local and economic value of tourism is estimated higher in a certain region than the money spent for farmers maintaining the landscape has to be analysed. Furthermore, little is known about the impact or potential contribution of different agricultural management types supporting certain ecosystem services (Tscharntke et al., 2005). Moreover, investigations on the multifunctionality of supported ecosystem services, as for example demonstrated by Klug and Zeil (2006), are poor so far.

Connecting the GIS analysis of subsidy payments based on administrative units with ecosystem services following natural boundaries was not an intended focus of this study. However, this analysis is important when trying to account the value of agrarian subsidy payments on ecosystem services. Different ecosystem services need to be mapped and spatially joined with the subsidy payments. Referring to the blue services required in the Mondsee catchment, buffer strips should be mapped as areas where the nutrient retention services are present. These areas need to be spatially joined with the subsidy payments to farmers. But as mentioned above, single subsidy instalments will affect manifold ecosystem services. Just to name a few,

- surface water bodies will be prevented from nutrients and thus almost no money needs to be spent for purification,
- water quality will increase and support the tourism industry,
- the drinking water reservoir will be maintained for water scarce seasons, and
- the fishery services will benefit due to viable, healthy and diverse fish populations.

This brief analysis shows that there are multiple benefits resulting from a single subsidy payment. Expressing these benefits in terms of money values and analysing the benefits spatially explicitly is an enormous challenge for future research.

Ecosystem services are present at different scales (carbon sequestration relevant on a global scale, water quality on regional scale, pollination on local scale). Dependent on the hierarchy of scales all services are demanded by society. Identifying how single parcels, an arrangement of parcels or even all parcels of a farm affect the landscape scale and thus ecosystem services (operating on different scales) has not been thoroughly analysed. Additionally, the forceful natural and anthropogenic processes working complementary to drive or even destroy ecosystem services cannot be understood in detail. One single process might support, decrease or even destroy an ecosystem service. Along with it, other ecosystem service might decrease as well or might be supported due to any kind of previous influence.

Ecosystem services are not only hard to quantify in monetary means; also societal attitudes are changing. When the nutrient status of e.g. the Mondsee Lake was bad in the past, the focus of local society and governments was on enhancing the blue services. Today more emphasis is placed on the yellow services. The priority is now given to secure work places, – a possible consequence induced by the present world economic crisis.

Since "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970), it is clear that in situ changes will also affect their surroundings. Changes on ecosystem services might also occur without a direct intervention but instead are distant driven (off-site changes). These might be shadow effects of local situations or plant pollination services resulting in changed species composition followed by a reduction of biodiversity (Tilman et al., 2002). Current debates on wide agricultural land abandonment in less favoured areas show significant impacts on ecosystem services (e.g. Asamer et al., 2009). For the Mondsee catchment, no such analysis has been developed so far. Nevertheless, direct impacts are expected on the currently prominent cattle farming practices and land use change. This might also have implication in the long run when agricultural fields are again needed to provide food security (Tilman et al., 2002).

5. Conclusion

Since ecosystem services depend on the number and type of species and composition of land use/land cover in an ecosystem, scientists struggle with the complexity when pricing ecosystem services. The analysed changes in spatially explicit agrarian subsidy distribution due to policy intervention are only a first step to analyse the impact of policy strategy changes on ecosystem services. The main information of what has really been lost in terms of money values has not been researched here. We recommend proceeding with research on an accounting procedure analysing the subsidy payment costs and their contribution (shares) to certain ecosystem services. It would help decision makers to see how much money is needed to keep certain services up and running. Additionally, farmers might get a better picture of other businesses they are directly or indirectly supporting. It might be a starting point for them to negotiate further funding for various other landscape services they provide. In future we expect that the farming business will provide more landscape services than "only" agricultural practices for food production. Pure subsidy considerations do not make sense in explaining changing ecosystem service conditions. Influences are e.g. also resulting from the incentive of the local populations, changing settlement conditions, industry developments, tourism activities and many other things, which need to be considered in future modelling approaches.

Politicians should carefully consider future incentive strategies and their impact on agriculture. The same applies to tax modifications and implementation of new regulations. In this respect, the main objectives are to establish sustainable practices ensuring properly working ecosystem services, the double benefit of farmers implementing sustainable practices and enabling landscape maintenance and society who is benefiting from the farmer's work. International agreed policies are needed to prevent counteracting of e.g. national policies against European or even worldwide strategies. Since environmental integrity and ecosystem services are working across boundaries (e.g. blue services concerning rivers systems), an internationally driven solution needs to be further developed. To achieve these objectives, coordination among federal agencies and responsible ministries is required. Since these institutions in most cases have different or even competing sub-objectives, a compromise is often hard to find. Awareness raising and capacity building is important to highlight the importance of different ecosystem services and explain them to the wider public using local examples directly affecting in situ population. Identifying pros and cons of afore mentioned competing sub-objectives might then become a new focus and stimulate public debates on ecosystem services demanded. Providing the "right" incentives, taxes, regulations etc. to consumers and/or producers should help maximising the total return of the net benefits of landscape maintenance and agricultural production to society.

Weblinks: http://tinyurl.com/56cezx [accessed 10.02.2009]: "Health Check" of the Common Agricultural Policy; http://tinyurl.com/5llqfv [accessed 10.02.2009]: Agriculture and the environment; http://tinyurl.com/6c7ofn [accessed 10.02.2009]: Rural Development policy 2007-201. Common monitoring and evaluation framework; http://tinyurl.com/8td92j [accessed 10.02.2009]: Rural Development policy 2007–2013.

References

Asamer, V., Klug, H., 2008. Evaluation des Einflusses agrarökonomischer Subventionen auf den Zustand der Landschaft. In: Strobl, J., Blaschke, T., Griesebner, G. (Eds.), Angewandte Geographische Informationsverarbeitung XX. Wichmann Verlag, Heidelberg, pp. 508–517.

Asamer, V., Braito, M., Breitwieser, K., Enengel, B., Silber, R., 2009. Abschätzung der Wahrscheinlichkeit einer Bewirtschaftungsaufgabe landwirtschaftlicher Parzellen mittels GIS-gestützter Modellierung (PROBAT). Diskussionspapier DP-42-2009 Institut für nachhaltige Wirtschaftsentwicklung. Web: http://tinyurl.com/l4r6qv.

Auswärtiges Amt, 2006. Die gemeinsame Agrarpolitik. http://tinyurl.com/bazt88 (accessed 10.02.2009).

Bastian, O., Steinhardt, U., 2002. Developments and Perspectives in Landscape Ecology. Dodrecht, Boston/London, 498 pp.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., et al., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.

Council Regulation (EC) No. 1698/2005.

Daly, H.E., 1992. Allocation, distribution, and scale: towards an economics that is efficient, just, and sustainable. Ecological Economics 6, 185–193.

de Groot, R., 2006. Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. Landscape and Urban Planning 75, 175–186.

de Groot, R., Wilson, M., Boumans, R., 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics 41, 393–408.

Farber, S.C., Costanza, R., Wilson, M.A., 2002. Economic and ecological concepts for valuing ecosystem services. Ecological Economics 41, 375–392.

Fischer Boel, M., 2008. Perspectives for the CAP in the Health Check and after 2013. SPEECH/08/577, http://tinyurl.com/3rqgmy (accessed 10.02.2009).

Heissenhuber, A., 2003. EU-Direktzahlungen–hängen davon die Zukunftschancen der Unternehmer ab? http://tinyurl.com/bva8m2 (accessed 10.02.2009).

IPCC, 2007. Climate Change. The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. ISBN 978 0521 88009-1.

Klug, H., 2010. Application of a vision in the Lake District of Salzburg. Futures. (submission: 19.10.2008/accepted: 07.07.2009/printed: Futures 42:8, October 2010).

Klug, H., 2007a. Participative landscape planning using a GIS approach for facilitation. In: Mander, U., Helming, K., Wiggering, H. (Eds.), Multifunctional Land Use: Meeting Future Demands for Landscape Goods and Services. Springer, Berlin, Heidelberg, pp. 195–233.

Klug, H., 2007b. Die naturräumliche und sozio-ökonomische Gliederung des Mondsee Einzugsgebietes. http://tinyurl.com/d5h2c3 (accessed 10.02.2009).

Klug, H., Lang, S., Pernkopf, M.-L., Zeil, P., 2007. Vorstellung einer Methode zur Ermittlung der Nutzungsintensität auf Grünlandflächen unter Einbezug von Fernerkundungsdaten und objekt-basierter Klassifikation. Schriftenreihe BAW 26, 51–65.

Klug, H., Zeil, P., 2008. Spatially explicit modelling of phosphorus emissions: integrating GIS and remote sensing for hydrologic modelling. Geoinformatics Magazine 8 (12/2008), 32–35.

Klug, H., Zeil, P., 2006. Bridging multi-functionality of agriculture and multifunctional landscapes by applying the Leitbild approach. In: Meyer, B.C. (Ed.), Sustainable Land Use in Intensively Used Agricultural Regions. Wageningen, pp. 82–90.

Millennium Ecosystem Assessment (MA), 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington, 155 pp.

Naidoo, R., Balmford, A., Costanza, R., Fisher, B., Green, R.E., Lehner, B., Malcolm, T.R., Ricketts, T.H., 2008. Global mapping of ecosystem services and conservation priorities. PNAS 105(28)-9495-9500. http://tinyurl.com/4fx68u (accessed 10.02.2009).

Oberösterreichische Landesregierung, 2004. Raumeinheit Attersee- Mondsee Becken, 87 pp. http://tinyurl.com/cwb5g8 (accessed 10.02.2009).

Parish, N., 2008. Speaking Note Neil Parish, Conference on Rural Development 16.10.2008. http://tinyurl.com/cj8ryh (accessed 10.02.2009).

Rounsevell, M., Reginster, I., Araujo, M.B., Carter, T.R., Dendoncker, N., Ewert, F., House, J.I., Kankaanpaa, S., Leemens, R., Metzger, M.J., Schmidt, C., Smith, P., Tuck, G., 2006. A coherent set of future land use change scenarios for Europe. In: Agriculture, Ecosystems and Environment, vol. 114, pp. 57–68, URL: http://tinyurl.com/3gva3w (accessed 10.02.2009).

Rural Development Regulation (1698/2005), support for rural development by the European Agricultural Fund for Rural Development (EAFRD), http://tinyurl.-com/al7gs2 (accessed 10.02.2009).

Schroers J.-O., 2006. Landnutzungsmodellierung mit ProLand. Datengrundlage und Aufbau der Datenbank. http://tinyurl.com/ceywvq (accessed 10.02.2009).

Silber, R., Wyrtzens, H.K., 2006. Modelling the probability of land abandonment at parcel level. In: Darnhofer, I., Schmid, E., Palkovics, M., Varga, G. (Eds.), Agriculture in Central Europe – Potentials and Risks. Dokumentation der 15. ÖGA-Jahrestagung in Keszthely, Hungary 29–30 September 2005. Facultas. Wien, pp. 55–63.

Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R., Polasky, S., 2002. Agricultural sustainability and intensive production practices. Nature 418, 671–677.

Tobler, W., 1970. A computer movie simulating urban growth in the Detroit region. Economic Geography 46 (2), 234–240.

Tscharntke, T., Klein, A.M., Kruess, A., Steffan-Dewenter, I., Thies, C., 2005. Landscape perspectives on agricultural intensification and biodiversity–ecosystem service management. Ecology Letters, 8 (8), 857-874.Varian, H.R., 1992. Microeconomic Analysis. New York. pp. 563, ISBN: 978-0393957358.

VO [EG] Nr. 1782/2003, establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers http://tinyurl.com/8xyxxn (accessed 10.02.2009).

VO [EG] Nr. 796/2004, rules for the implementation of cross-compliance, modulation and the integrated administration and control system, http://tinyurl.com/bm7yhq (accessed 10.02.2009).

Von Thünen, J. H., 1826. Der isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie oder Untersuchungen über den Einfluss, den die Getreidepreise, der Reichtum des Bodens und die Abgaben auf den Ackerbau ausüben; erste Auflage, Hamburg.

Zeil, P., Klug, H., Niemeyer, I., 2008. GIS and RS: monitoring environmental conventions and agreements. In: Monitoring Environment and Security: Integrating Concepts and Enhancing Methodologies. BICC Publications, brief 37, pp. 53–59.