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Socioeconomic effects of a bottom-up multifunctional land consolidation project

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ABSTRACT

Taking agricultural land out of production or shifting from crop production to permanent grassland have recently been proposed in Denmark as general measures for contributing to greenhouse gas (GHG) reductions. One of the particular features of such measures is the creation of co-benefits, as taking agricultural land out of intensive production may affect a range of ecosystem services and economic goods, such as reduced nutrient loads and emissions of GHGs, improved biodiversity, and improved recreational opportunities. In this paper, we present results from an *ex ante* socioeconomic Cost-Benefit Analysis (CBA) with the purpose of assessing whether the expected benefits of a bottom-up local development plan for multifunctional land use in the catchment of Lake Glenstrup in Denmark will outweigh the expected costs. After quantifying the wide range of impacts, we apply benefit transfer to value them within the CBA framework. Among the primary effects are reduced emission of GHGs, reduced leaching of nutrients, increased recreational options, and opportunity costs from agriculture. The results indicate that the initiatives could lead to a net social gain of 1.4 mil. €. We perform a sensitivity analysis which shows that the choice of the spatial extent of the recreational effects has a large impact on the results, which range from 0.4 to 5.2 mil. €. Also, the shadow price of reduced GHG emissions play a major role. Finally, a distribution analysis shows that especially farmers bear the majority of costs, whereas other stakeholders enjoy most of the benefits.

1. Introduction

Intensification of agriculture and transformation of other land uses into agriculture have caused a steep increase in the environmental pressures from agriculture during the late 20th century (Tilman, 1999). Coupled with extensive use of pesticides and fertilizers, and increasing numbers of livestock, this has not only resulted in increased eutrophication of water bodies and loss of biodiversity. It has also increased LULUCF (Land use, land-use change and forestry) GHG emissions, for instance in terms of N_2O emissions from organic soils (Schulze et al., 2009). Policies addressing these externalities have mainly been focused on reducing the use of detrimental inputs and implementing green technologies. Recently, two of the major Danish NGOs, the Danish Agriculture and Food Council and The Danish society for Nature Conservation, suggested that the environmental and climate goals should be pursued by a multifunctional land reform, which would involve taking 100,000 ha of agricultural land out of production. Similar recommendations are given by the Danish Council on Climate Change as one element of the pathway to reach a 70% GHG emission reduction target in 2030 in Denmark (Danish Climate Council, 2020). While GHG emission reductions may be the main policy target, converting 100,000 ha of land from agricultural production to multifunctional land use will have a wide range of impacts. Assessing the economic efficiency of such a multifunctional land reform policy thus requires comprehensive analysis tools capable of encompassing and summarizing the multifaceted impacts on societal welfare. Against this backdrop, this paper provides a case-study based empirical exemplification of how socio-economic analyses can be used for assessing the desirability of a multifunctional land reform policy at the local level.

A number of socio-economic studies involving land restoration with a multifunctional view exists in the literature. In a Danish context Dubgaard et al. (2001) provides one of the first example of utilizing the framework on the 'Skjern-River project' a 2200 re-establishment of nature. The analysis shows that recreational values and biodiversity

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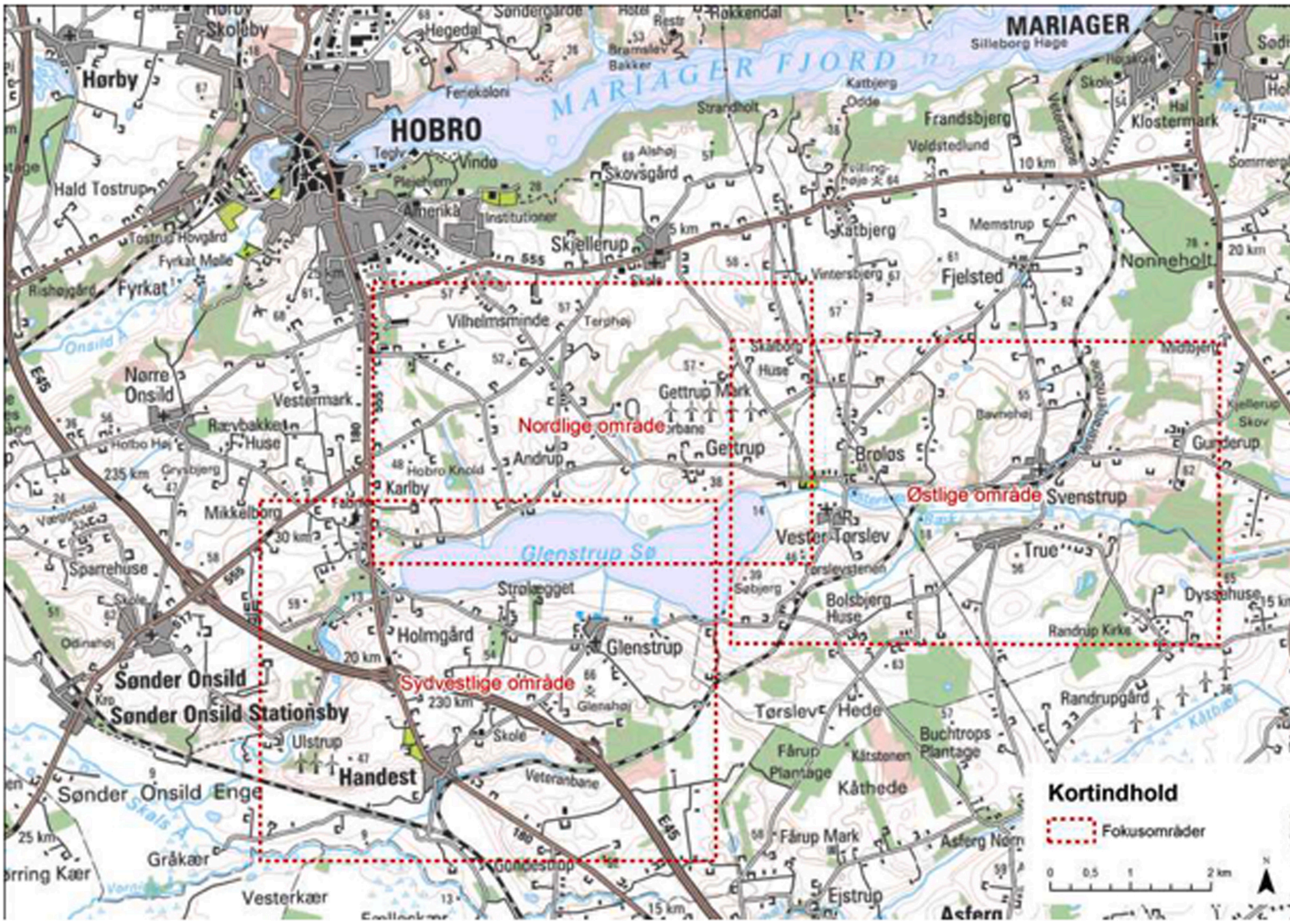

Fig. 1. The location of the project area, with Lake Glenstrup in the middle. The red dotted squares outline the specific areas affected by the development plan. Explanation of the Danish signatures on the map: Nordlige område: Area North; Østlige område: Area East; Sydvestlige område: Area Southwest.
Source: Johansen et al. (2020).

values play a significant role in the overall assessment. Schou et al. (2021) represents a more recent application of social CBA at a nature restoration in Store Blåkilde in Denmark. de Groot et al. (2022) apply a social CBA to a landscape restoration in Spain. The analysis involves different land use systems, including a multi-functional land use system and they conclude that using a social CBA gives a better picture of the true welfare effects of landscape restoration and that a transition from conventional monoculture to multi-functional land use is only feasible if all externalities are accounted for. Galler et al. (2015) compare different management strategies by quantifying cost efficiency for erosion prevention, water quality conservation, climate change mitigation and biodiversity in Verden, Germany. They find that biodiversity measures and climate change mitigation generally have high multifunctional effects.

The present study extends on the indicator approach used in Johansen et al. (2018) by applying a CBA to analyse the socioeconomic properties of a multifunctional land use project initiated by the Danish Collective Impact Initiative in the catchment of lake Glenstrup, Denmark. To clarify the use of the terms “multifunctional” and “bottom up”, land-use projects often depart from one objective, e.g. biodiversity, aquatic environment, recreation, or GHG reductions. However, the project at Lake Glenstrup is not targeting a single, specific objective. Instead, using a bottom-up planning process, local citizens were invited to put forward their ideas, representing many different objectives, hence the multifunctionality. These ideas were subsequently incorporated in a Local Development Plan which serves as the point of departure for this CBA. Thus, the CBA evaluates the suggestions resulting from the bottom up process, but the findings from the CBA have not as such affected the bottom-up process.

Previous studies have found that increasing the multifunctionality of the catchment area of Lake Glenstrup in Denmark yields a higher level of sustainability (Johansen et al., 2020). They found that all the sustainability criteria were mutually dependent. Furthermore, they identified some key trade-offs especially between farm economy, rural development and effects on the environment, recreational use and biodiversity. However, while qualitative criteria were instrumental in Johansen et al. (2020), in this study we take an economic valuation approach to evaluate the same bottom-up local development plan of multifunctional land use in the Lake Glenstrup catchment area in Denmark (from here on referred to as the “development plan”) by using CBA. This approach appraises marketed as well as non-marketed impacts of a project or policy in a full socioeconomic analysis, monetizing costs and benefits of all impacts to enable calculation of a single welfare measure in terms of the net present value (NPV) indicating the social desirability of the project or policy (Hanley and Barbier, 1993). The exploration of NPV is mostly carried out from a utilitarian perspective in which the utility of all individuals is aggregated and the effect is considered from a marginal point of view (See Turner, 2007 for an extensive review of the CBA method in European Environmental policy). Therefore, distributional consequences of a policy are commonly disregarded in CBA since distributional issues are political in nature (Vining and Weimer, 2006). Nevertheless, to make policy choices transparent, the distributional effects should be quantified to support collaboration with private interests and increase the acceptability of the regulatory mechanisms (Sterner

Table 1
The 17 initiatives from the development plan included in the analysis.

Initiative	Ha	Km	Financial economic effect	Public goods and externalities affected
Afforestation	38.2		Economic rent of forest Opportunity cost of arable land	Recreational use Recreational hunting Emissions of GHG, N, P and NH_3
Public orchard	7.5		Apple harvest Opportunity cost of arable land Establishment and maintenance cost	Recreational use Recreational hunting Emissions of GHG, N, P and NH_3
Extend existing trail network by the lake		4.0	Establishment and maintenance cost of trail and recreational facilities	Recreational use
Joint grazing area by the lake	132.0		Economic rent of low input grazing Opportunity cost of arable land	Recreational use Recreational hunting Emissions of GHG, N, P and NH_3
Demolition of abandoned houses in local city			Cost of demolition Costs of establishment a park on the site	Amenity value of urban revitalization
Church path		8.0	Establishment and maintenance cost of trail and recreational facilities	Recreational use
Shelters near local runic stone	3.3	6.5	Establishment and maintenance cost of trail and recreational facilities	Recreational use
Joint grazing on the slopes of the stream	218.4		Economic rent of low-input grazing Opportunity cost of arable land	Recreational use Recreational hunting Emissions of GHG, N, P and NH_3
Reopening the piped stream	32.6		Economic of low-input grazing Opportunity cost of arable land Cost of reopening stream	Recreational use Recreational hunting Emissions of GHG, N, P and NH_3
Restoring old fish ponds and stream	20.6		Economic rent of low-input grazing Opportunity cost of arable land Cost of clearing scrubs	Recreational use Recreational hunting Emissions of GHG, N, P and NH_3
Recreational trails and access to the lake		6.0	Establishment and maintenance cost of trail and recreational facilities	Recreational use
Low-input grazing and access to nature area	14.3		Economic rent of low-input grazing Land rent of extensive grazing Opportunity cost of arable land	Recreational use
Low-input grazing on local landmark	47.9	1.4	Economic rent of extensive grazing	Recreational use Recreational hunting Improved biodiversity[a]
Low-input grazing on the northern banks of the lake	38.5		Economic rent of low-input grazing Opportunity cost of arable land	Recreational use Recreational hunting Emissions of GHG, N, P and NH_3
Re-stablishment of stream	15.8		Economic rent of low-input grazing Opportunity cost of arable land	Recreational use Recreational hunting Emissions of GHG, N, P and NH_3
Recreational trail along railway		15.9	Establishment and maintenance cost of trail and recreational facilities	Recreational use
Land consolidation of agricultural land	200	580	Reduced costs to road maintenance Improved productivity in agriculture	Reduced congestion, traffic noise, and accidents

Source: Mariagerfjord Kommune (2019). [a]While many of the initiatives are generally considered supportive of biodiversity, this is the only area where biodiversity is expected to markedly improve (Ejrnæs et al., 2018).

et al., 2019). To explore this further, the CBA presented here also provides an analysis of the distribution of costs and benefits among different stakeholders.

2. The project

The project originates from the Danish Collective Impact Initiative initiated by the Foundation Realdania. The idea is to introduce goals of multifunctional land use in land consolidation processes accounting for societal needs related to land use and thereby contribute to the sustainability agenda (Johansen et al., 2020; Hartvigsen, 2014). To demonstrate the potentials, four real-life projects were initiated in the Danish Collective Impact Initiative, and the catchment of Lake Glenstrup was one of these. Lake Glenstrup in the municipality of Mariagerfjord is 4.5 km long, covers 384 ha and is 31 m deep at its deepest point. It is a popular recreational fishing location for brown trout, pike, European perch and common whitefish. The current land use in the surrounding catchment is dominated by agricultural land in crop rotation.

The municipality of Mariagerfjord was appointed to facilitate the project and organize the development of a development plan involving locals, politicians, NGOs and industry (Fig. 1). Thus, the development plan represents a localized vision for the catchment area surrounding Lake Glenstrup. Based on the initiatives in the development plan we have developed the specific multifunctional land use scenario subject of the analysis.

The overall target of the development plan was to reduce negative externalities and provide public goods to society. The proposed development plan consists of 36 specific initiatives for local land use changes suggested by stakeholders (Mariagerfjord Kommune, 2019). Of the 36 initiatives, 19 were considered outside the scope of this study as they did not contribute to the provision of public goods or the reduction of externalities from agricultural land use. Table 1 provides an overview of the remaining 17 initiatives, including the spatial extent used for their valuation and whether they are expected to have a positive or negative effect on marketed as well as non-marketed impacts on societal welfare. All these initiatives are accounted for in the CBA.

3. Method

The CBA provides a methodology for analyzing the aggregate socioeconomic effects of all the initiatives presented in Table 1. The framework is based on the aggregation of the total economic value of a project to provide input for decision and policy-making and this includes

Table 2
Quantifications of physical effects and unit values.

Effect	Quantification (Physical effect)	Source of quantification	Unit value (in 2019 consumer prices)	Method and source of unit value
Improved recreational opportunities	2684 hh/year	Own estimate based on population statistics	37 €/hh/y	Stated preferences (Uggeldahl and Olsen, 2019)
Reduced GHG emissions	2770 kg/ha/y	Own estimate based on Dubgaard and Ståhl (2018)	33 €/ton/y	Shadow price (Dubgaard and Ståhl, 2018)
Reduced P emissions	10 kg/ha/y	Own estimate based on Jacobsen (2012)	85 €/kg/y	Shadow price (Jacobsen, 2012)
Reduced N emissions	40 kg/ha/y	Own estimate based on Jacobsen (2017)	3 €/kg/y	Shadow price (Jacobsen, 2017)
Reduced NH_3 emissions	2.5 kg/ha/y	Own estimate based on Dubgaard and Ståhl (2018)	8 €/ha/y	Shadow price (Dubgaard and Ståhl, 2018)
Reallocation of cropland resulting from the land consolidation: – Increased productivity – Reduced external effects on public roads	200 ha 580 km	Own estimate based on Olsen et al. (2017) Own estimate based on Olsen et al. (2017)	26 €/ha/y 0.4 €/km/y	Modeling of reduced costs from time spent and tear on ag. vehicles (Olsen et al., 2017) Unit transfer of standardized costs (Kofoed-Wiuff, 2015)
Improved biodiversity	47.9 ha	Development plan	213 €/ha/y	Stated preferences (Dubgaard et al., 2001; Willis, 1996)
Improved hunting grounds: – Agriculture – Forestry	100 ha 36 ha	Development plan Development plan	9 €/ha/y 34 €/ha/y	Price observations (Lundhede et al., 2015)
Costs of nature restoration	33 ha	Development plan	1.6 €/ha/y	Unit transfer of standardized costs on Fejerskov et al. (2019)
Costs of new recreational facilities	42 km trails 4 sets of shelters and tables Maintenance costs	Development plan	1706 €/km 2000 € per set of shelters and tables 138 €/km/y	Own market observations of investment and maintenance costs
Process costs	Project management Land consolidation process		117,000 €/y the first 4 years	Budget of the project
Agricultural opportunity costs: – Cropland – Grassland	145 ha 520 ha	Development plan	290 €/ha/y -269 €/ha/y	Economic rent (SEGES, 2019 and Thomsen et al., 2018)

Note: Some minor effects associated with a new orchard, a new forest, and demolition of condemned houses are left out for brevity. These are available in Appendix A.

both marketed and non-marketed effects (OECD, 2018). The aggregate evaluation of benefits (*B)* and costs (*C*) is presented as the net present value (NPV) to allow for an even comparison between costs and benefits that are unevenly placed in time utilizing the principle of discounting (Hanley and Barbier, 2009); see Eq. (1).

$$NPV = \sum_{t=0}^{T} \frac{B_t^i - C_t^i}{(1+r)^t} \tag{1}$$

where B_t^i is the benefit in period t from good i, C_t^i is the cost in period t from good i, r is the discount rate, and T is the time horizon of the analysis.

The discount rate adjusts the benefits and costs depending on when they occur, incorporating the fact that benefits and cost occurring in the future are generally considered of less value than if they had occurred today. This is partly based on the assumption that there will be economic growth in society which on average will make people richer. Combined with the standard assumption of decreasing marginal utility of income, this means that for instance consumption of some good will be worth more to us today than saving the good for consumption in the future. Another reason for discounting relates to the so-called pure time preference, which reflects the behavioral tendency that people in general put higher value on e.g. consuming some good today rather than tomorrow simply because there is a risk of not surviving until tomorrow. This is the background for the Ramsey equation, which describes the social discount rate as a composition of the pure time preference and the product of assumed growth rate and elasticity of marginal utility of consumption. (OECD, 2018). The applied discount rate may have a major impact on the result of the CBA and is therefore a topic of controversy (see Beckerman and Hepburn, 2007). The EU guidelines on CBA have adjusted the suggested appropriate magnitude of the discount rate over the past 15 years in three separate issues of guidelines (European Commission, 1997, 2008, 2014). The current recommendation is to use a discount rate of 3% in high-income countries and 5% in low-income countries (European Commission, 2014). In Denmark, at the time of study, the official national guidelines were to use a discount rate of 4% when dealing with time periods shorter than 35 years (Ministry of Finance, 2017).

In this study, a project time period of 20 years (*T*) is used as this corresponds to the time horizon for some of the subsidy schemes supporting low input grazing under the CAP. All the economic effects are presented in 2019-prices and subsequently converted to Euro using an average exchange rate of 1€ ~ 7.5DKK. As the prices of agricultural land and environmental benefits are compared, all values are presented at the consumer level. To adjust factor prices to the consumer level, in line with national guidelines we apply a standard conversion factor of 1.28 which approximates the average Danish level of VAT and other taxes (Ministry of Finance, 2017).

When activities are publicly funded or supported by public financed subsidies, they cause a deadweight loss because of distortions to the production/consumption relationship from deriving the public funding through tax policies (Browning, 1976; Ministry of Finance, 2017). This is also known as the Marginal Cost of Public Funds (MCPF). We follow the current Danish guidelines and add 10% to the costs that are funded by public funds to approximate the MCPF (Ministry of Finance, 2017). More specifically, the MCPF in this analysis applies to about half of the subsidies for low input grazing under pillar II of the Common Agricultural Policy as this is the share of the subsidy financed by the Danish Finance Act.

The analysis is static comparative and focuses on the direct effects of the various initiatives and land use changes. Therefore, derived effects in other sectors, e.g. on tourism and on the land market, are not reflected in the results.

3.1. Quantification of benefits and costs

In the following, the practical approach for assessing the aggregate effects and attaching economic values are explained. Table 1 identified a variety of different effects reflecting the multifunctional nature of the planned land consolidation initiatives. In the following, we provide more details regarding the different approaches used to transfer the physical effects and unit values to the scenario developed for the Lake Glenstrup area. This is summarized in Table 2.

3.2. Recreational benefits

We estimate the recreational benefits first assuming that all the 2684 households located in parishes within the project area will enjoy the improved recreational opportunities. The number of households in the area is based on the number of citizens in the area divided by the national average of household residents (DST, 2020). We multiply the number of households with a unit value estimate obtained from Uggeldahl and Olsen (2019). Based on a choice experiment study, they estimated an average willingness to pay of 37 € per year per household in Northern Denmark for establishing new walking paths in some of the riparian buffer strips in Northern Denmark. This number pertains to improved recreational opportunities similar to those envisaged in the scenario for the Lake Glenstrup area, which is also located in Northern Denmark. However, it reflects valuation of an improvement covering a considerably larger geographical area. The Lake Glenstrup project area is a few hundred hectares, whereas the region of Northern Denmark covers almost 800,000 ha. On one hand, this might suggest that the value estimate from Uggeldahl and Olsen (2019) would overestimate the recreational value generated by the Lake Glenstrup project. On the other hand, walking paths in riparian buffers will most likely primarily generate use values in terms of everyday recreational walking trips. Such values are likely subject to distance decay in the sense that the value declines the further away from the recreation site a household is located, and the value further declines when substitute sites are present closeby (e.g. Jørgensen et al., 2013; Olsen et al., 2020). The value estimate in Uggeldahl and Olsen (2019) could thus be suspected to mainly reflect value associated with areas close to where people live, even though the scenario described covered a larger area. Also, their value estimate reflects an average covering many different areas of varying recreational quality. Arguably, the recreational quality of the scenario for the Lake Glenstrup project, which also entails adding more recreational facilities, would be above average and with relatively few substitutes of equal quality nearby. This would suggest that the value estimate from Uggeldahl and Olsen (2019) might not necessarily overestimate the recreational value generated by the Lake Glenstrup project. Furthermore, this value estimate is quite similar to values found in a travel cost study by Bjørner and Termansen (2014) addressing recreational values in nature areas.

The benefit transfer function used to calculate the aggregate value for the improvement in recreational opportunities is outlined in Eq. (2):

$$B_R = p_R n_R \tag{2}$$

where B_R is the benefit of increased recreational options, p_R is the price per unit for recreational benefits per household, and n_R is the number of households.

Recreational hunting and fishing is not included in the above valuation of improved recreational opportunities. Using the model of Lundhede et al. (2015), we estimate the current value of hunting (expressed in terms of the hunting lease prices) for the 138 ha of land in crop rotation to be 25 €/ha per year and 42 €/ha per year for land with forest production. The change to more extensive agriculture and the forestation has, according to the empirical findings in Lundhede et al. (2015) a positive effect on hunting values, and the values used here are the marginal effects related to these changes. Regarding recreational fishing, Lake Glenstrup is known to be home to pike, perch and common whitefish, but it is also subject to eutrophication due to nutrient runoff resulting in massive algal blooms during the summer season (Ejrnæs et al., 2018). Reduced nutrient loss, e.g. resulting from changed land use in the catchment, would most likely improve water quality and thereby increase the value of recreational fishing (Lipton and Hicks, 1999; Rask et al., 2010). Since quantitative data on recreational fishing in Lake Glenstrup was not available at the time of writing, we have not been able to directly include the benefits from improved recreational fishing. However, this aspect is indirectly covered to some extent through inclusion of the values of the reduced nutrient leaching.

3.3. Nitrogen, phosphorus and GHG emissions

Nitrogen (N) and phosphorus (P) leaching from agriculture are subject to regulation because of targets set for freshwater quality in the Water Framework Directive. Targets for GHG reductions from agriculture are set by the targets for the non-quota sector. Jacobsen (2017) used an emission factor for nitrogen leaching of 40 kg N/ha per year on organic soils. As most of the areas considered for conversion to permanent grassland are adjacent to the lake, and, thus, have a high content of organic matter, we apply this estimate. The valuation of N is calculated by applying shadow prices, representing the marginal price of reaching the existing Danish policy target. Jacobsen (2017) calculates the cost per kg N reduction for reaching the policy targets to be 3 €⁄kg N. Applying a similar approach, Dubgaard and Ståhl (2018) find an emission of ammonia of 2.51 kg/ha per year and a value of 6 €⁄kg N. Ideally, a preference-based estimate should have been used for assigning a value to the N reductions, since the shadow price is connected with uncertainty as it reflects the ambitions and implementation of the current policy which might not be fully in line with the preferences of society, see e.g., Bradford (1975). However, there is a broad tradition for estimating the costs of agri-environmental policies in Denmark and, thus, a systematic and well-documented basis for estimating shadow prices for various policy objectives. This is unfortunately not matched by a similar catalog of preference-based unit values for the effects of nutrient losses.

P leaching decreases when land use changes from intensive agriculture to permanent grass on areas close to the lake serving as P-buffer zones. As a result of the land consolidation process farmers with need for land for spreading manure are offered this on areas with no risk of P-leakage and, thus, they may sustain their current activities. Jacobsen (2012) and Schou et al. (2007) show that the decrease is in the interval between 10 and 30 kg/ha/year. We use the lower bound of this estimate at 10 kg/ha/year. As P pollution results in a stock externality, we assume that the effect in terms of reducing the P stock in the sediment of Lake Glenstrup is linear over the project period of 20 years. Jacobsen (2012) finds a shadow price of 67 €/kg P for particularly polluted freshwater areas, corresponding to Lake Glenstrup, which frequently experiences algal blooming of *Cyanobacteria*.

Taking low-lying organic soils out of rotation and managing them as permanent grassland without drainage or application of fertilizers is expected to reduce GHG emissions by 15.2–40.2 t CO_2-eq/ha/year (Dubgaard and Ståhl, 2018). We apply a simple average of 27.7 t CO_2-eq/ha/year. The shadow price of reducing GHG is 26 €/t CO_2-eq. This shadow price is based on a Danish target of reducing GHG emissions by 39% compared to the reference year 2005 in the non-ETCS sectors. However, recent policy discussions point in the direction of a 70% reduction target in 2050. A recent analysis from The Danish Climate Council (2020) has shown that employing such an ambitious target would drive the shadow price up to 200 €/t/year in 2030. We use a shadow price of reducing GHG of 26 €/t CO_2-eq in the baseline scenario and apply the value from The Danish Climate Council (2020) for sensitivity analysis.

The benefit transfer function used to calculate the value of these emissions is outlined in Eq. (3):

$$B_s = p_s e_s A_s \tag{3}$$

where B_s is the benefit of reduced emission of environmental stressor (s), p_s is the price per unit for emission of s, e_s is the emission of s ha^{-1} from low-input grazing, and A_s is the affected number of hectares.

3.4. Land reallocation

Land reallocation will lead to increased productivity in agriculture due to reductions in transport with agricultural vehicles on public roads and thus save work hours for farmers (Olsen et al., 2017). Furthermore, fewer agricultural vehicles also lead to decreased wear on public roads and reduces congestion, traffic effects, accidents and noise by up to 0.4 €/km (Kofoed-Wiuff, 2015).

3.5. Biodiversity

The value of improving biodiversity in the Lake Glenstrup area should be evaluated based on the effects on nonuse values if the project decreases the risk of losing endangered species. A distinction between the instrumental or functioning value of biodiversity and the service or good it provides to people is important to avoid double counting (Mace et al., 2012; Pascual et al., 2017). The nonuse value of biodiversity is quite well described in a Danish context (Jacobsen and Thorsen, 2010; Lundhede et al., 2014; Strange et al., 2007), but linking land use change to changes in biodiversity is challenging. A very recent Danish consensus report from IPBES DK describes five options to counter biodiversity loss in Denmark, two of which are to restore natural hydrology and reduce fragmentation by creating small natural areas (Barfod et al., 2020). The proposed initiatives in the local development plan are set to restore natural hydrology in a larger area, increase the area with low-input cattle grazing, and create small nature areas that will serve as steppingstones towards a more heterogeneous landscape. While this is likely to generally support biodiversity in the local area, the effect on biodiversity seen from a national perspective is arguably minimal, and it has not be possible to quantify the expected change as such. However, in one particular area it is assessed that conversion to low-input grazing will avoid overgrowth that would otherwise lead to a loss of endangered plant and insect species currently present in that area (Ejrnæs et al., 2018). It is reasonable to assume that this would contribute to protect biodiversity at a national level beyond what may be considered negligible. Hence, this will likely increase biodiversity nonuse values among the general population in Denmark. The nonuse value of improved biodiversity is estimated by simple unit value transfer. We use the same unit value for biodiversity nonuse value that was used in similar Danish CBA studies on land use change and nature restoration reported in Dubgaard et al. (2001). The value estimate originates from a Contingent Valuation study addressing use and nonuse values associated with a wildlife enhancement scheme in Pevensey Levels in the UK (Willis, 1996). While more recently conducted Danish valuation studies of biodiversity are available in the literature (e.g. Jacobsen and Thorsen, 2010; Lundhede et al., 2014; Strange et al., 2007), none of them specifically estimate only non-use value in a context that we consider sufficiently similar to the Lake Glenstrup project to justify using them as unit value in a practical benefit transfer. Another reason for using the same unit value as in Dubgaard et al. (2001) is to remain conservative and avoid over-estimation of benefits, since this value estimate is rather low compared to other estimates of biodiversity non-use values. The unit value solely represents nonuse values and it summarizes the benefits of the entire Danish population for improving biodiversity in a hectare of land. The unit value is multiplied by the number of hectares in the project area where the initiatives are expected to markedly improve biodiversity from a national perspective, c.f. Table 1.

Table 3
Decomposition of the economic effects.

Effect	Present Value (1000 €)
Recreation	1741
GHG	1358
P	737
N	551
Reallocation of land	469
Biodiversity	139
Recreational hunting	24
Nature restauration costs	-49
Marginal costs of public funds	-100
Costs of recreational facilities	-154
Other effects[a]	-369
Process cost	-426
Opportunity cost of cropland	-572
Low-input grazing	-1900
Net Present Value	**1449**

[a] Include the net value of orchard, forest and demolition of condemned houses.

Table 4
Sensitivity analysis.

	Parameter change	NPV (mil €)	
		Change	Total
Baseline scenario	–	–	1.4
Scale of recreational benefit: Local area	from 2684–622 households	-1.0	0.4
Regional area	from 2684 to 10,128 households	3.8	5.2
No effect on nutrients & GHG	Change in emissions of N, P and GHG set to 0	-2.6	-1.2
No effect on P	from 10 kg to 0 kg/ha per year	-0.7	0.7
Large effect on P	from 10 kg to 20 kg/ha per year	0.7	2.2
New policy target for GHG	from 33 to 200 €/t CO_2-e	9.0	10.5
New policy target for GHG and no other benefits	all benefits 0 and 200 €/t CO_2-e	7.8	9.2
Biodiversity benefit on all areas with low-input grazing	extra 138 ha with biodiversity benefits	0.4	1.8

3.6. Administrative costs and opportunity cost from agriculture

We assess the resources allocated for project management from the budget of the Collective Impact secretariat of 117,000 €/year in the first four years of the project when the development plan is implemented. This covers the land allocation process, public administration, facilitation of involving local stakeholders, property registration fees, etc.

The opportunity costs of crops in rotation are estimated as the loss of the economic rent from cropping spring barley, which is the most common crop in the area (Ejrnæs et al., 2018). We assume no effect on livestock production and other activities. Low-input grazing on permanent grasslands generally results in a negative farm-economic rent (Dubgaard et al., 2012; Thomsen et al., 2018; Schou et al., 2020) and is eligible for agri-environmental subsidies under pillar II of the Common Agricultural Policy. As the EU funds half of the subsidy, this transfer it is regarded as benefit to the Danish society. However, low-input grazing still results in a negative economic rent.

4. Results

Comparing the costs and benefits of all the marketed as well as non-marketed effects of the considered initiatives of the multifunctional development plan, we find a positive NPV of about €1.4 mil over the 20 year project time horizon. In Table 3., the distribution of cost and benefits can be seen over the span of effects. Changing agricultural practices exhibits the most prominent effect on agricultural income, as Table 3 reveals the development plan would bring about a negative aggregate

Table 5
Distribution of economic effects divided into commodity production (marketed goods) and non-commodity production (non-marketed goods).

	Commodity production	Non-commodity production
Recreation		37%
GHG		32%
P		17%
N		13%
Reduced wear on roads		9%
Increased efficiency from reallocation of land		2%
Biodiversity		3%
Hunting	-1%	
Nature rehabilitation costs		-1%
MCPF		-2%
Orchard net able income	-1%	
Forest net wood income	4%	
Arable land - land rent	31%	
Low input grassing	67%	
Process cost		-10%
SUM	100%	100%

cost from low-input grazing of €− 1.9 mil. However, considering just the effects on recreation and GHG emissions, the benefits are above €3 mil.

4.1. Sensitivity analysis

We conducted a sensitivity analysis on key parameters to evaluate the robustness of the result on the following key parameters: the scale of recreation from local to regional; no effects on emissions of nutrients and GHG; effect on P of 0 kg and 20 kg per ha; shadow price of GHG reductions based on the new policy pathway. The results of the sensitivity analysis are shown in Table 4. We find that the conclusion is sensitive to the choice of the boundaries of the recreational benefits. For instance, if the recreational benefits are assumed only to apply to the 622 households located in the rural communities within the catchment of Lake Glenstrup, the NPV is reduced to €0.4 mil. The conclusion is particularly sensitive to the estimated values of the expected N, P and GHG emission reductions. If applying the extreme assumption that there will be no reductions in N and P emissions the NPV turns negative at €− 1.2 mil. However, this would seem very unrealistic as Denmark has committed to the EU Water Framework Directive, and a major component of compliance is reduction in eutrophication of water bodies. Turning to the effect of GHG-emissions, when applying a shadow price reflecting the new Danish policy target of 70% GHG emission reduction by 2050, the value of the expected reduction in GHG emissions alone substantially outweighs the aggregate costs, thus rendering the project socioeconomically desirable even disregarding all other benefits.

4.2. Distributional incidence of costs and benefits

Table 3 shows that the majority of the positive effects (recreation, climate effects, reduced nutrients, biodiversity, etc.) are public goods that benefit society as a whole. It thus indicates a significant distributional shift from benefits of the land mainly being enjoyed by farmers to benefits of the land mainly being enjoyed by the wider society. The standard CBA essentially employs the Kaldor-Hicks efficiency criteria, stating that a project represents a socially beneficial reallocation of resources if the losers of the project or policy can potentially be fully compensated by those benefitting from the project, of if the losers can bribe the winners of the project or policy to forgo the benefits. Focusing only on *potential* compensations, corresponding to the concept of potential Pareto improvements, the Kaldor-Hicks efficiency criteria does not require that actual transactions take place between winners and losers of a project. As such any distributional effects are disregarded. However, when observing political decision processes, distributional effects within the economy often appear to be one of the most important considerations as it relates directly to voters. To shed light on the distributional effects, Table 5 provides an illustration of the division of the costs and benefits depending on whether they relate to the production of marketed and non-marketed goods.

The table shows that the effects on marketed goods represent the main part of the costs, whereas the provision of non-marketed goods represents the main part of the benefits. This indicates that the economic effects are unevenly distributed between different stakeholders, as especially stakeholders related to farming are subject to costs whereas the benefits mainly occur to individual citizens in the broader society. If the changes in land use are to be effectuated voluntarily this indicates a need for applying actual compensations or subsidies to those experiencing a loss in income, in order to avoid reluctance from the local stakeholders.

5. Conclusions and discussion

The multifunctionality or joint production of agricultural land use is one of the key arguments behind the recent development of the EU Common Agricultural Policy (Paarlberg et al., 2002; Dobbs and Pretty, 2004; Alons, 2017). Land consolidation projects are well known as a measure for promoting productivity in agriculture (Wojewodzic, 2021). However, in Denmark recent policies have broadened the scope in terms of using multifunctional land consolidation to pursue more sustainable land use in rural areas, including societal goals related to biodiversity, economic development, environment, climate change, and outdoor recreation (Johansen et al., 2020). From an economic point of view, multifunctional land consolidation can be considered a mechanism for addressing the multiple benefits and external costs related to land use changes. To assess the societal desirability of such a multifunctional land consolidation development plan, we have performed a societal CBA for a proposed local development plan for the catchment of Lake Glenstrup in Denmark.

We find that the scenario represented in the local development plan of multifunctional land use in the Lake Glenstrup catchment area results in a positive NPV of €1.4 mil over a 20-year time horizon. Several factors influence the result. Whereas the costs are rather robust as they are based on observed costs and costs derived from the quantified land use changes, the benefit side is highly dependent on the underlying assumptions. This goes for the value of the improved recreational opportunities, which especially depend on the number of households expected to enjoy the recreational benefits. Also, assumptions concerning the societal value of reducing GHG emissions prove crucial for the magnitude of benefits. In addition, the benefit estimates in the presented analysis do not reflect irreversible and nonlinear consequences, such as is likely the case in relation to climate change (Lenton et al., 2019; Solomon et al., 2009). This could imply that we may underestimate the present value of the benefits. However, given that the climate change effects of the GHG emissions related to the Lake Glenstrup catchment are truly marginal on a global scale, it seems reasonable to disregard such effects in the current case.

The various benefits driving the positive NPV show that focusing on multifunctional land use may improve the societal gain from agri-environmental initiatives compared to the status quo. Both at the national and EU level, current agri-environmental policies tend to have a one-dimensional focus, e.g., the Water Framework Directive and the Habitat Directive, leading to policies that at best are separable but at worst work against each other (Dulluri and Raţ, 2019; Janauer et al., 2000). Our study shows that by applying a thorough CBA of projects expected to contribute to multiple societal benefits, these benefits become apparent, and the implicit prioritization between different goods and policy objectives following from different project outlines becomes more transparent to decision makers and stakeholders.

Current agri-environmental policy developments focus on land use changes and different approaches to land management both within the EU common agricultural policy (Heyl et al., 2020) and in national policies addressing the biodiversity crisis, e.g., through rewilding (Svenning et al., 2019). Ideally, the multiple benefits resulting from changes in land use should be valued through primary valuation studies. These would address the concrete change at the concrete place and thus present a more precise value estimate. This would, however, require considerable resources and therefore we use benefit transfer which offers an attractive practical approach to perform a quantitative economic assessment of the benefits. During the past 30 years, considerable research efforts have provided methodological advances and useful insights into the socioeconomic values of nature and environmental goods both internationally (Tinch et al., 2019) and in Denmark (Schou et al., 2018). Notwithstanding this, the use of such value estimates in practical policy evaluations has not received the same attention. Additionally, if specific policies exist for improving the provision of environmental goods, and these policies are supported by cost-efficiency analysis, this can also provide data for the assessment of benefits in terms of shadow prices. Our case study demonstrates how a CBA can be performed based on benefit transfer when multiple benefits arise from a project reallocating land use. It also points to the importance of continuing efforts to provide valid valuation data and developing and sharing experiences regarding benefit transfer methods to further improve the economic input to decisions aimed at environmental protection, biodiversity, and land use policy.

The major strength of CBA is to provide comparable estimates of the socioeconomic cost and benefits from reallocation of societal resources, in the present case a reallocation of land use. This is due to a stringent theoretical and methodological basis for the analysis and the ability to condense all impacts into a single informative figure, i.e. the NPV, summarizing all costs and benefits over the time horizon of the project. This enables comparison across different projects and to the ability to explore effects of various scenarios and policy implementations. However, for the purpose of stakeholder involvement a CBA can go hand-in-hand with for example indicator based evaluation tools as demonstrated in Johansen et al. (2018) as these tools make the effects more transparent and allow for direct involvement of field-experts.

One specific feature of the presented CBA is that it assesses the outcome of a bottom up participatory planning process. Thus, it covers a number of citizen driven initiatives and the aggregate effect of these incur changes at the local community level and landscape level. While the CBA was not as such part of the bottom-up planning process, the overall project setting is compatible with the conditions for a bottom-up CBA outlined in Carolus et al. (2018). These conditions are that no a priori choices were made regarding the policy objectives or measures, relevant stakeholders were identified and invited into the idea generating process, and the process was run at a representative scale. Thereby the results support the idea of CBA being applicable in bottom up processes as suggested in Carolus et al. (2018) even though the feedback from the CBA to the process is not part of the current project. Furthermore, the analysis demonstrates how such complex and large-scale multifunctional projects with various types of costs and benefits can be subject to a CBA. Although the results from the CBA were provided after the actual bottom-up process of collecting ideas from the local communities, the results have been utilized in the continued decision-making process in several ways. Results were communicated to the stakeholders of the Danish Collective Impact Initiative as inspiration before the finalization of the final development plan. This provided important insight which was used in the final decisions, e.g. in terms of an understanding of the importance of the recreational benefits and how the scale of these both depend on the potential number of users and the investments and maintenance costs of the recreational infrastructure.

Another important contribution of the study is the documentation of the net benefits following from a large, multifunctional project origination from a citizen driven bottom up process. Although such processes also require considerable resources, the ideas developed thru the process actually result in provision of both public goods and reduces environmental pressures that by far outweigh the costs. Thereby the CBA approach makes an important and substantial contribution to the work presented in Johansen et al. (2018). Whereas the indicator based approach in Johansen et al. (2018) is focused on demonstrating potentials and inspiring the citizen driven process, the CBA demonstrates the central tradeoffs between benefits and costs, and enables systematic evaluation of various scenarios and alternatives as well as comparison to other land reallocation projects for which a CBA has been performed.

Looking at the contribution of this study compared to similar CBAs of Danish land-use projects (e.g. Dubgaard et al., 2001; Schou et al., 2021) the overall results are similar as they also generally find positive NPVs. One significant difference, however, is that this CBA demonstrates that recreational benefits may be substantial and in fact the most important social benefit whereas the majority of other studies primarily are driven by benefits enhancing the provision of environmental services such as improved terrestrial and aquatic biodiversity or reduced emissions of GHG. In this respect, the findings also are in line with Konrad et al. (2017) who find significant synergies between various ecosystem services related to land use but also point to the need to take costs into consideration when regulating the services.

Last, compared to the current policy, the local development plan is considered the only policy option or scenario in this analysis. This is because the development plan was developed through a bottom-up process involving both citizens, NGOs and other stakeholders. Thus, it represents a compromise among their various interests. It could be argued that the same level of benefits that result from the development plan may be provided at lower costs through more targeted policies by applying a traditional optimization approach. However, it is an insight in itself that the proposed development plan following from a process of stakeholder involvement actually results in a robust socioeconomic surplus.

CRediT authorship contribution statement

Jesper Sølver Schou did the Funding acquisition, Conceptualization, choice of Methodology, Project administration, Data analysis, and review & editing of the paper. **Gustav Marquard Callesen** participated in the data analysis, and did the first draft of the paper. **Thomas Hedemark Lundhede** contributed with choice of Methodology, data, and review & editing. **Søren Bøye Olsen** contributed with choice of Methodology, data, and review & editing.

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Appendix A

See Table A1.

Table A1
Data for assessing the economic effects of the orchard, land rent of forest, demolition of condemned houses, and so-called "other effects" in the results section.

	Quantity	Value	Method
Orchard establishment cost	8 ha	42,666 €/ha	Quantity: development plan Value: (Ørum, 2010)
Revenue from orchard	6.500 kg/ha per year	0,5 €/kg	Quantity: Own assessment. Value: We assume 50% of the calculated market price
Economic rent of forest	38 ha	213 €/ha per year	Quantity: development plan Value: (DORS, 2015)
Cost of demolition	1 house	22,186 €	Quantity: development plan Value: (Kristensen et al., 2017)
Benefit of demolition	15 houses	2333 €/house	Quantity and value: own assessment based on rural real-estate prices

References

Alons, G., 2017. Environmental policy integration in the EU's common agricultural policy: greening or greenwashing? J. Eur. Public Policy 24 (11), 1604–1622.

Barfod, A., Bruun, H.H., Clausen, P., Egemose, S., Ejrnæs, R., et al. 2020. Genopretning Af Biodiversitet Og Økosystemer [Resoring Biodiversity and Ecosystems].

Beckerman, W., Hepburn, C., 2007. Ethics of the discount rate in the stern review on the economics of climate change. World Econ. 8 (1), 187–210.

Bjørner, T.B., Termansen, M., 2014. Brugsværdien af naturområder i Danmark [Use value of natureareas in Denmark]. Djøfforlag 1–23.

Bradford, D.F., 1975. Constraints on government investment opportunities and the choice of discount rate. Am. Econ. Rev. Vol. 65, 887–899.

Browning, E.K., 1976. The marginal cost of public funds. J. Political Econ. 84 (2), 283–298.

Carolus, J.F., Hanley, N., Olsen, S.B., Pedersen, S.M., 2018. A bottom-up approach to environmental cost-benefit analysis. Ecol. Econ. 152 (2018), 282–295.

Danish Climate Council, 2020. Kendte veje og nye spor til 70 procents reduktion [known ways and new tracks for a 70% reduction]. ⟨file:///Users/SimonStrand/Downloads/70_pct_analyse.pdf⟩.

de Groot, R., Moolenaar, S., de Vente, J., De Leijster, V., Ramos, M.E., Robles, A.B., Schoonhoven, Y., Verweij, P., 2022. Framework for integrated Ecosystem Services assessment of the costs and benefits of large scale landscape restoration illustrated with a case study in Mediterranean Spain. Ecosyst. Serv., 53, 101383.

Dobbs, T.L., Pretty, J.N., 2004. Agri-environmental stewardship schemes and "multifunctionality". Rev. Agric. Econ. 26 (2), 220–237.

DORS, 2015. Økonomi og Miljø 2015. [Economy and Environment], De Økonomiske Råd/Danish Economic Cluncils.

DST, 2020. FAM55N. Husstande 1. Januar Efter Kommune, Husstandstype, Husstandsstørrelse Og Antal Børn i Husstanden. ⟨https://www.statbank.dk/fam55N⟩.

Dubgaard, A., Jespersen, H.M.L., Laugesen, F.M., Hasler, B., Christensen, L.P., 2012. Økonomiske Analyser Af Naturplejemetoder i Beskyttede Områder [Economic Analysis of Nature Management Methods in Protected Areas], Fødevareøkonomisk Institut, Københavns Universitet. Rapport / Fødevareøkonomisk Institut, Nr. 211.

Dubgaard, A., Kallesøe, M.F., Petersen, M.L., Damgaard, C.K., Erichsen, E.H., 2001. Velfærd og økonomi i rakation til biologisk mangfoldighed og naturbeskyttelse [Welfare and Eceonomics in Relation to Biodiversity and Nature Protection]. ⟨www.sns.dk⟩. (Accessed 27 April 2020).

Dubgaard, A., Ståhl, L., 2018. Omkostninger ved virkemidler til reduktion af landbrugets drivhusgasemissioner. Opgjort i relation til EU's 2030-målsaetning for det ikke-kvotebelagte område. [Cost of policies to reduce agricultural GHG emissions. Considered in relation to the EU target, Københavns Universitet. IFRO Rapport, Nr. 271. ⟨www.ifro.ku.dk/publikationer/ifro_serier/udredninger/⟩. (Accessed 23 April 2020).

Dulluri, A., Raţ, D., 2019. The green-green dilemma reconciling the conflict between renewable energy and biodiversity. J. Health Environ. Educ. 11, 6–14. https://doi.org/10.18455/19002.

Ejrnæs, R., Johansen, P.H., Kronvang, B., Olsen, J.V., Præstholm, S., et al., 2018. Screening af Potentialer Ved Multi-Funktionel Jordfordeling Ved Glenstrup Sø Og Østerkær Bæk i Mariagerfjord Kommune [Screening of Potentials from Multi-Functional Land Redistribution near Genstrup Lake and Østerkær Stream in Mariagerfjord Municipality]. ⟨https://findresearcher.sdu.dk:8443/ws/portalfiles/portal/145575081/Potentialer_ved_multifunktionel_jordfordeling_ved_Glentrup_S_og_sterk_r_B_k.pdf⟩.

European Commission, 1997. Guide to Cost-Benefit Analysis of Investment Projects.

European Commission, 2008. Guide to Cost Benefits Analysis of Investment Projects. ⟨http://doi.org/10.11646/zootaxa.1910.1.6⟩.

European Commission, 2014. Guide to Cost-Benefit Analysis of Investment Projects. ⟨http://doi.org/10.2776/97516⟩.

Fejerskov, M.L., Alnøe, A.B., Kristensen, E.A., Jepsen, N., 2019. Virkemidler til forbedring af de fysiske forhold i vandløb. Version 2 [Measures for improving the physical status of streams. Version 2]. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 70 s - Videnskabelig rapport nr. 341. ⟨http://dce2.au.dk/pub/SR341.pdf⟩.

Galler, C., von Haaren, C., Albert, C., 2015. Optimizing environmental measures for landscape multifunctionality: effectiveness, efficiency and recommendations for agri-environmental programs. J. Environ. Manag. 151, 243–257.

Hanley, N., Barbier, E., 2009. Pricing Nature: Cost-Benefit Analysis and Environmental Policy. Edward Elgar, Cheltenham.

Hanley, N., Barbier, E.B., 1993. Pricing Nature – Cost-Benefit Analysis and Environmental Policy, Aldershot, Hants, Aldershot, Hants.

Hartvigsen, M., 2014. Land consolidation and land banking in Denmark – tradition, multi-purpose and perspectives. Dan. J. Geoinform. Land Manag. 47, 1–7.

Heyl, K.T., Döring, B., Garske, J., Stubenrauch, F. Ekardt, 2020. The common agricultural policy beyond 2020: a critical review in light of global environmental goals. Rev. Eur. Comp. Int. Environ. Law doi.org/10.1111/reel.12351.

Jacobsen, J.B., Thorsen, B.J., 2010. Preferences for site and environmental functions when selecting forthcoming national parks. Ecol. Econ. 69 (7), 1532–1544.

Jacobsen, B.H., 2012. Analyse Af Skyggepris På Fosfor Med Udgangspunkt i Omkostninger Ved at Reducere Fosfortabet Til Vandmiljøet [Analysis of the Shadow price of Phosphorus through the Cost of Reducing Phosphorus Leaching to the Water]. FOI Udredning; No. 2012/27). ⟨www.ifro.ku.dk/publikationer/ifro_serier/udredninger/⟩.

Jacobsen, B.H., 2017. Beregning Af Kvaelstofskyggepris Med Udgangspunkt i Fødevare- Og Landbrugspakken [Calculating the Shadow Price of N Using the Food and Agriculture Policy Legislation]. IFRO Udredning, Nr. 2017/08. ⟨www.ifro.ku.dk/publikationer/ifro_serier/udredninger⟩.

Janauer, G.A., Albrecht, J., Stratmann, L., 2000. Synergies and conflicts between water framework directive and natura 2000: legal requirements, technical guidance and experiences from practice. In: Ignar, S., Grygoruk, M. (Eds.), Wetlands and Water Framework Directive Protection, Management and Climate Change. Springer GeoPlanet: Earth and Planetary Sciences. ISBN 978-3-319-13763-6.

Johansen, P.H., Ejrnæs, R., Kronvang, B., Olsen, J.V., Præstholm, S., Schou, J.S., 2018. Pursuing collective impact: a novel indicator-based approach to assessment of shared measurements when planning for multifunctional land consolidation. Land Use Policy 73 (102–114). https://doi.org/10.1016/j.landusepol.2018.01.040.

Johansen, P.H., Ejrnæs, R., Kronvang, B., Olsen, J.V., Præstholm, S., Schou, J.S., 2020. Exploring the interdisciplinary potential of the Agenda2030—interactions between five Danish societal demands for sustainable land use. Land Use Policy.

Jørgensen, S.L., Olsen, S.B., Ladenburg, J., Martinsen, L., Svenningsen, S.R., Hasler, B., 2013. Spatially induced disparities in users' and non-users' WTP for water quality improvements—testing the effect of multiple substitutes and distance decay. Ecol. Econ. 92, 58–66.

Kofoed-Wiuff, A., 2015. Eksternaliteter Fra Tung Transport [Externalities from Heavy Transport]. Working Paper EA Energianalyse. ⟨https://www.ea-energianalyse.dk/wp-content/uploads/2020/02/1459_eksternaliteter_tung_transport_fremgangsmaade.pdf⟩.

Konrad, M.T., Andersen, H.E., Gyldenkærne, S., Termansen, M., 2017. Synergies and trade-offs in spatially targeted water quality and climate change mitigation policies. Land Econ. 93 (2), 309–327.

Kristensen, N., Kolodziejczyk, C., Wittrup, J., 2017. Nedrivninger Af Huse Og Fremtidige Nedrivningsbehov i Danmark [Demolition of Houses and Demolition Need in Denmark], Report, KORA. ⟨https://www.forskningsdatabasen.dk/en/catalog/2440218222⟩.

Lenton, T.M., Rockström, J., Gaffney, O., Rahmstorf, S., Richardson, K., et al., 2019. Climate tipping points — too risky to bet against. Nat. Res.

Lipton, D.W., Hicks, R., 1999. Linking water quality improvements to recreational fishing values. The case of chesapeake bay striped bass. Evaluating the Benefits of Recreational Fisheries, pp. 105–110.

Lundhede, T.H., Jacobsen, J.B., Hanley, N., Fjeldså, J., Rahbek, C., et al., 2014. Public support for conserving bird species runs counter to climate change impacts on their distributions. PLoS ONE 9, 7. https://doi.org/10.1371/journal.pone.0101281.

Lundhede, T.H., Jacobsen, J.B., Thorsen, B.J., 2015. A hedonic analysis of the complex hunting experience. J. For. Econ. 21 (2), 51–66.

Mace, G.M., Norris, K., Fitter, A.H., 2012. Biodiversity and ecosystem services: a multilayered relationship. Trends Ecol. Evol. 27 (1), 19–26.

Mariagerfjord Kommune, 2019. Lokal Udviklingsplan for Glenstrup Sø og Østerkær Bæk - Fælles Forandring – vejen til en bedre brug af det åbne land [Local Development Plan for Glenstrup sø and Østerkær bæk]. Rapport, Mariagerfjord kommune.

Ministry of Finance, 2017. Vejledning i Samfundsøkonomiske Konsekvensvurderinger [Guidelines to CBA]. ⟨https://www.fm.dk/publikationer/2017/vejledning-i-samfundsoekonomiske-konsekvensvurderinger⟩.

OECD, 2018. Cost Benefit Analysis And The Enviroment: Further Developments And Policy Use. OECD Publishing, Paris.

Olsen, S.B., Jensen, C.U., Panduro, T.E., 2020. Modelling strategies for discontinuous distance decay in willingness to pay for ecosystem services. Environ. Resour. Econ. 75, 351–386.

Olsen, J.V., Czekaj, T.G., Henningsen, A., Schou, J.S., 2017. The Effect of Land Fragmentation on Farm Performance: A Comprehensive Farm-Level Study from Denmark. Paper for The XV EAAE Congress Parma, August 29th – September 1st 2017.

Ørum, J.E., 2010. Om Etablering Og Drift Af Konventionelle Og Økologiske Æbleplantager [Establishment and Management of Conventional and Organic Able Farms]. Techinal note.

Paarlberg, P.L., Bredahl, M., Lee, J.G., 2002. Multifunctionality and agricultural trade negotiations. Rev. Agric. Econ. 24 (2), 322–335.

Pascual, U., Balvanera, P., Díaz, S., Pataki, G., Roth, E., et al., 2017. Valuing nature's contributions to people: the IPBES approach. Curr. Opin. Environ. Sustain. 26–27, 7–16.

Rask, M., Olin, M., Ruuhjärvi, J., 2010. Fish-based assessment of ecological status of Finnish lakes loaded by diffuse nutrient pollution from agriculture. Fish. Manag. Ecol. 17 (2), 126–133.

Schou, J.S., Jensen, J., Thorsen, B.J., 2018. Sæt pris på naturen [Pricing Nature]. Institut for Fødevare- og Ressourceøkonomi, Københavns Universitet. ISBN: 978-87-92591-87-6, p. 176.

Schou, J.S., Jensen, R.B., Lundhede, T., Olsen, S.B., 2021. Samfundsøkonomisk cost-benefit-analyse af naturgenopretningsprojekt ved Villestrup Å og Store Blåkilde. IFRO Rapport; Nr. 300. Institut for Fødevare- og Ressourceøkonomi, Københavns Universitet, 35 s [Cost-benefit anaysis of restoration of hydrological processes at Villestrup å and Store Blåkilde].

Schou, J.S., Kronvang, B., Birr-Pedersen, K., Jensen, P.L., Rubæk, G.H., et al., 2007. Virkemidler Til Realisering Af EUs Vandrammedirektiv [Measures for fulfilling the EU WFW Directive], Udredning for udvalg nedsat af Finansministeriet og Miljøministeriet: Langsigtet indsats for bedre vandmiljø. ⟨https://www2.dmu.dk/pub/fr625_final.pdf⟩.

Schou, J.S., Bladt, J., Ejrnæs, R., Thomsen, M.N., Vedel, S., Fløjgaard, C., 2020. Economic assessment of rewilding versus agri-environmental nature management. AMBIO. ⟨https://orcid.org/0000-0001-5030-4035⟩.

Schulze, E.D., Luyssaert, S., Ciais, P., Freibauer, A., Janssens, I.A., et al., 2009. Importance of methane and nitrous oxide for Europe's terrestrial greenhouse-gas balance. Nat. Geosci. 2 (12), 842–850.

SEGES, 2019. Budgetkalkyle: Vårbyg. Farmtal Online. ⟨https://farmtalonline.dlbr.dk/Kalkuler/VisKalkule.aspx?Prodgren=K_1010⟩. (Accessed 6 November 2019).
Solomon, S., Plattner, G.K., Knutti, R., Friedlingstein, P., 2009. Irreversible climate change due to carbon dioxide emissions. Proc. Natl. Acad. Sci. USA 106 (6), 1704–1709.
Sterner, T., Barbier, E.B., Bateman, I., van den Bijgaart, I., Crépin, A.S., et al., 2019. Policy design for the anthropocene. Nat. Sustain. 14–21.
Strange, N., Jacobsen, J.B., Thorsen, B.J., Tarp, P., 2007. Value for money: protecting endangered species on Danish heathland. Environ. Manag. 40 (5), 761–774.
Svenning, J.-C., Munk, M., Schweiger, A., 2019. Trophic rewilding: ecological restoration of top-down trophic interactions to promote self-regulating biodiverse ecosystems. In: du Toit, J.T., Pettorelli, N., Durant, S.M. (Eds.), Rewilding. Cambridge University Press, Cambridge, pp. 73–98.
Thomsen, M.N., Vedel, S.E., Schou, J.S., 2018. Driftsøkonomiske Konsekvenser Ved Etablering Af Store Sammenhaengende Naturområder-Fire Cases [Private economic CBA of Establishing Large Connected Nature Areas – Four Cases], IFRO Udredning, Nr. 2018/05. ⟨www.ifro.ku.dk/publikationer/ifro_serier/udredninger/⟩. (Accessed 22 April 2020).
Tilman, D., 1999. Global Environmental Impacts of Agricultural Expansion: The Need for Sustainable and Efficient Practices. National Academy of Sciences Colloquium "Plants and Population: Is There Time?" Held December 5–6, 1998, at the Arnold and Mabel Beckman Center in Irvine, CA. Global. Vol. 96, pp. 5995–6000.
Tinch, R., et al., 2019. Economic valuation of ecosystem goods and services: a review for decision makers. J. Environ. Econ. Policy, 8(4): Special Issue: Natural Capital and Natural Capital Accounting, pp. 359–378.
Turner, R.K., 2007. Limits to CBA in UK and European environmental policy: retrospects and future prospects. Environ. Resour. Econ. 37 (1), 253–269.
Uggeldahl, K.C., Olsen, S.B., 2019. Public preferences for co-benefits of riparian buffer strips in Denmark: an economic valuation study. J. Environ. Manag. 239, 342–351.
Vining, A.R., Weimer, D.L., 2006. Efficiency and cost-benefit analysis. Handbook of Public Policy, Vol. 58, pp. 417–432.
Willis, K.G., 1996. Benefits and costs of the wildlife enhancement scheme: a case study of the pevensey levels. J. Environ. Plan. Manag. 39 (3), 387–402.
Wojewodzic, T., Janus, J., Dacko, M., Pijanowski, J., Taszakowski, J., 2021. Measuring the effectiveness of land consolidation: an economic approach based on selected case studies from Poland. Land Use Policy. https://doi.org/10.1016/j.landusepol.2020.104888.