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Pursuing collective impact: A novel indicator-based approach to assessment of shared measurements when planning for multifunctional land consolidation

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1. Introduction

Competition for space is a recurrent issue in land use planning and there is a constant need to adjust existing allocation of land as societal demands change over time. In a historical perspective, land allocation has primarily served the interests of production and habitation, but today environmental and cultural demands need consideration too. In response to the challenges arising from the increased number of stakes on land, attention amongst planners and researchers has been directed at the multifunctional potentials of landscapes but also at land consolidation as a means to address a multitude of developing issues. This article contributes threefold to this debate within land policy and planning by providing a suggestion for an indicator approach applied to an illustrative case from Denmark.

Firstly, our study contributes to the policies and planning of multifunctional landscapes. Multifunctional land use in agricultural, forested or urban areas is directly, although not exclusively, linked to the different functions that the land can provide (e.g. Marsden and Sonnino, 2008; Carvalho-Ribeiro and O'Riordan, 2010; Aubry et al., 2012). These include traditional production functions, ecological and environmental functions, cultural functions and recreational functions (Jongeneel et al., 2008). Multifunctional landscapes can simultaneously fulfil different combinations of these functions. Within landscape ecology, landscapes were described as multifunctional due to their spectrum of different ecological, land use and even transcendental functions (Brandt and Vejre, 2004; de Groot et al., 2002). Similar efforts at describing multiple functions of ecosystems have targeted valuation of services and benefits rather than narrow functions (Costanza et al., 1997; de Groot et al., 2002; Plieninger et al., 2013; Pröbstl-Haider, 2015; Vejre et al., 2010). A well-studied example of multifunctional land use is the narrow strip of land along watercourses (buffer zones) that has long been a feature of the agricultural landscapes. The scientific basis for judging the best course of action in designing, placing, balancing economic costs and benefits of such buffer zones has increased over the last few years (Stutter et al., 2012; Münch et al., 2016). Many of the policies that directly affect buffer strips have complex interactions, such as between food production, diffuse pollution mitigation, climate change and biofuel production, natural flood management, greenhouse gases and soil carbon, and biodiversity. Yet, these policies are often conceived and applied independently but within the same landscape. Therefore, there is a need for understanding how we can move towards a more holistic system of valuing and accounting for the multiple functions of beneficial landscape features. This article addresses this need by providing a novel suggestion for an interdisciplinary, coordinated and easily communicated and applicable tool for policy and planning of multifunctional land use.

Secondly, our study contributes to policy and planning when applying land consolidation for increasing the multifunctionality of the landscape. While both 'multifunctional' and 'land consolidation' often appear in the literature regarding structural changes in the agricultural sector, land consolidation has typically involved a more narrow monofunctional focus. In the international literature on land consolidation, attention is directed at farm level and at optimisation of production and income in response to increased fragmentation of farmed land. An example is a study of 12 land consolidation projects in Finland that aimed at measuring the cost reductions from an optimised allocation of lots (Hiironen and Riekkinen, 2016). Huylenbroeck et al. (1996) introduced a multidisciplinary method for evaluating the impact of land consolidation for production at farm level. Evaluation methods of this kind address the EU agricultural policy and the agricultural programmes that

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aim for a more multifunctional use of farmland. They exemplified their methods by applying it to cases from Portugal and Belgium and concluded that countries with a well-structured farming sector have taken advantage of land consolidation as a powerful tool to overcome 'transition problems caused by the reform of the Common Agricultural Policy and to cope with the ecological degradation of rural areas' (pp. 309). Also broader social aims of land consolidation have been investigated by, for instance, Miranda et al. (2005) who carried out an analysis of the impact of land consolidation on rural development since the 1950's. They suggested five measures for evaluation: property structure, land use, intensity of production, emigration and socio-economic factors. Their findings showed that in Galicia, Spain, land consolidation has been an important planning instrument for rural development; however, they also pointed to the need for tools to improve the selection of areas for land consolidation. Moreover, they emphasised the problems of streamlining land consolidation planning and impact measuring due to the EU agricultural subsidy programmes. Their arguments highlighted the differences between nations and regions, especially whether the emphasis is on farm level, on community level or on regional level. Although the Dutch and Danish approaches are often mentioned together, some decisive differences should be stressed, related to, for instance, the enforcement regime. In Denmark, land consolidation is voluntary, whereas Dutch legislation allows for both voluntary and compulsory actions. Here, compulsory land consolidation originally included a majority vote for approval but is now up to the provincial parliaments (Leenen, 2014). The German approach, including five different land consolidation approaches, has also been used as example of effective land consolidation (Hartvigsen, 2015). The novel interdisciplinary indicator-based screening tool, suggested in this article, meets the call for methods for streamlining and impact measuring multifunctional land consolidation across different approaches. In addition, the screening tool operates at farm level, community level, regional level and international level.

Thirdly, our study contributes to the policy and planning debate about shared measurement in processes applying the *Collective Impact* framework (Kania and Kramer, 2011). Five important conditions empower the process of the Collective Impact. A key condition is the achievement of a *common agenda*. In the context of Collective Impact, the common agenda is an optimal (sustainable) land use planning across stakeholders. A *continuous communication* and *mutually reinforcing activities* strengthen the dialogue for finding a common ground, whileas *back bone support* by professionals facilitates the process. The final condition, *shared measurement,* establishes a sound and emergent set of data, available to all parties in the process, enabling them to target the overall aims of the collective impact. The societal challenge about how to meet the multiple demands on land is complex and the stakeholders often take deeply personal and emotional stands, often in opposition to each other. To avoid the risk of symptom treatment rather than general solutions for sustainable multifunctional land use, this article suggests that shared measurement should be anchored in research-based knowledge and that shared measurement should built on agreement among stakeholders based on disseminated knowledge from the policy relevant research fields. In addition, the article directs attention to the indicators as a communication tool for developing a common agenda for the project areas as part of the collective impact process. The role of the involved research fields is illustrated in Fig. 1. Though land consolidation is the primary driver for change, in this case, the framework could serve equally well as framework for other processes in landscape planning.

1.1. The Danish case

The novel research-based indicator approach suggested in the article is developed on the background of a Danish project. Acknowledging an increasing pressure on land use from production, leisure and environmental sustainability as well as a general depopulation trend in the countryside, a Danish initiative was taken in 2014 to unite stakeholders within the framework of Collective Impact in a concerted action to break new grounds for a better-coordinated and more multifunctional use of Danish landscapes. Within this initiative, national stakeholders representing agriculture, forestry, conservation, recreation and regional authorities set out the common agenda to introduce land consolidation as a future way of improving the multifunctionality of the landscape. In Denmark, land consolidation has more or less been on the agenda since the land reforms in the late 18th century. Agricultural land fragmentation addresses the interaction between farm productivity and the size, shape and location of the fields (Latruffe and Piet, 2014). If fields are small, have odd shapes or are located at large distance of the farm buildings, the variable costs of production and, thus, farm productivity, will be affected negatively because of increased labour costs, reduced capacity of the farm machines and restrictions on crop choice (Olsen et al., 2016). In Denmark, land consolidation projects can be driven by landowners alone, but because of the need for coordination between landowners they are most often facilitated by a "central planner" – either the Division of Land Consolidation under the Ministry of Environment and Food or private consultants. Haldrup (2015) presents the process undertaken in Danish land consolidation projects and highlights the voluntary approach. In the last 20 years, land consolidation has evolved from primarily aiming at improving farm productivity to also dealing with more complex land use problems. In particular, land consolidation has been applied to facilitate projects aiming at restoration of wetlands or other types of extensive land use on former farmland, in order to enhance the production of environmental (public) goods. In this case, the landowners need to be compensated for the restrictions in land use; for instance in the form of pecuniary transfers to the affected landowners or purchases by the central planner of land, which is then offered as compensation for the loss of farming opportunities (Hartvigsen, 2014). The stakeholders in the Collective Impact working group, who possessed knowledge of the Danish traditions on land consolidation, decided to launch a pilot project that involved a financed facilitation of land consolidation with a municipality as project owner, the local population as stakeholders and voluntary landowners as key players. Hence, the shared measurement in the Danish collective impact initiative needs to address the intended multifunctional outcome of land consolidation projects. To provide the shared knowledge base, the stakeholder agreed on relevant research fields and invited us as a group of researchers representing five disciplines: environmental protection of freshwater bodies, outdoor recreation, farm economics, rural development and biodiversity conservation, to participate in the project.

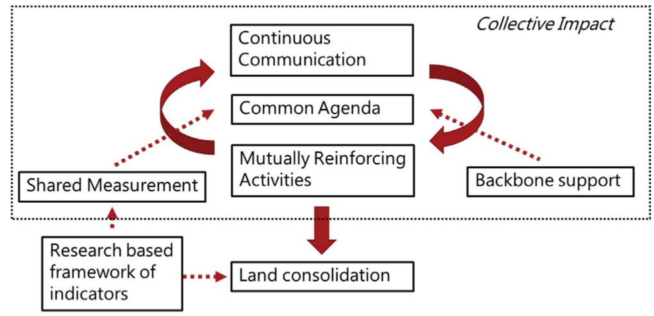

Fig. 1. The five conditions of the collective impact process are within the dotted box. The interplay between continuous communication, mutually reinforcing activities and finding a common agenda is facilitated by backbone support and shared measurement. The research-based framework of indicators contributes to the shared measurement and can be used to evaluate the results of the land consolidation following the collective impact.

2. Interdisciplinary method for shared measurement for screening and evaluating land for multifunctional land consolidation

In order to evaluate and communicate about the multiple outcomes of a modern land consolidation concept, we selected five indicators within each of the five academic disciplines: environmental protection, outdoor recreation, farm economics, biodiversity conservation and rural development. The choice of five indicators balanced between having a variety of indicators within each field and keeping the model simple and easy to communicate for the stakeholders, planners and policy makers. Also it took into consideration that each field should be accounted for and that each indicator should be relevant and possible to evaluate, both empirically and based on expert judgment in the initial project phase before land consolidation had been accomplished. The indicators are motivated and explained below for each of the five evaluated aspects of land consolidation effects.

2.1. The indicators

2.1.1. Farm economic indicators

The farm economic indicators aim at reflecting factors affected by the land allotment, which is expected to be of primary importance for the economic performance of the farm. Thus, effects on other persons or firms are not reflected by the indicators. Five indicators were chosen based on a review of the literature on allotment and farm productivity (see Olsen et al., 2016): Soil quality (FE1); Road transport (FE2); Utilisation of machinery (FE3); Regulation (FE4) and Flexibility (FE5).

2.1.1.1. FE1. Soil quality. Soil quality is a determinant for crop yields and here maps of soil texture are combined with the location of the single fields. Changes in land quality, resulting from land consolidation, may affect the economic potential of the farm as factors such as crop choice and need for irrigation, may be affected by the soil quality.

2.1.1.2. FE2. Road transport. Road transport with farm machinery is quantified by modelling the distance from farm buildings and the single fields and the results are used to estimate the time used for transport. Transport distances are calculated using road network distances in a GIS based on geo-referenced maps of the farm fields and farm buildings derived from the Danish Agrifish Agency, The Danish Ministry of Environment and Food.

2.1.1.3. FE3. Utilisation of machinery. Utilisation of machinery is represented by the time spent per hectare on field operations. Cost savings will occur if land consolidation leads to less road transport, larger fields or more simple field operations. The shape index used is called the minimum bounding rectangle area index and is calculated as the area of the field divided by the area of the smallest enveloping rectangle. The aggregated index at farm level is calculated as the area-weighted index for all the fields. The minimum bounding rectangle calculation is a feature in most GIS-software.

2.1.1.4. FE 4. Regulation. Regulation is based on an assessment of the legal restrictions on farming practices on the specific fields. If land consolidation leads to a re-allocation of the fields belonging to a farm, this may result in changes in regulations, for instance mandatory reductions in fertilizer use or protected cultural heritage landscape elements, which may affect the farming practices.

2.1.1.5. FE5. Flexibility. Flexibility is an indicator of the possibilities of the farmer to adapt to changes in general economic conditions. For example, if land consolidation results in location of the fields adjacent to the farm buildings, the farmer may be able to engage in organic dairy farming, which would be more difficult if the fields were located at greater distance from the farm buildings.

Scoring of the potential for the five farm economic indicators is done both based on data and on qualitative assessments. For indicators FE1, FE2 and FE3 maps of soil quality and statistics on field sizes, field location and transport networks are applied, whereas the scoring of indicators FE4 and FE5 is based on qualitative evaluation using observations from visits in the area.

2.1.2. Environmental indicators: monitoring points

The environmental indicators aim at reflecting factors that act as important pressures impacting the status of the aquatic environment involving also mitigation measures that can counteract or reduce the pressure-impacts. The indicators chosen follows the Driving Force, Pressure, Impact and Response (DPSIR) causal framework for describing the interactions between society and the environment: Nitrogen emissions (EN1); Phosphorus emissions (EN2); Ochre and sediment pollution (EN3); Ecological quality (EN4) and Mitigation measures (EN5).

2.1.2.1. EN1. Nitrogen emissions. Nitrogen (N) leaching to groundwater and emissions to surface waters are an important part of the implementation of the EU Nitrates Directive (ND) and the Water Framework Directive (WFD) in Denmark as the N loading to most estuaries and several protected groundwater aquifers has to be reduced according to the River Basin Management Plan 2 (RBMP) (Ministry of Environment and Food, 2016). Therefore, changes in N emissions to groundwater and surface waters as an effect of land consolidation in the project areas are an important and will be quantified using two existing N models for a baseline period of 3 years before and a period after land consolidation to best possible filter out the climate signal. We will apply an empirical nitrate leaching model (NLES4) developed based on plot or field scale observations of nitrate leaching from the root zone on agricultural land in Denmark (Kronvang et al., 2008). The model predicts the annual N leaching based on a range of input variables derived from national registers of climate data, soil types, crop types and annual N input and output at field scale in Denmark. The resulting changes in N loadings to surface waters in the project areas will be quantified utilising a newly developed national consensus model for N leaching, N retention and N loadings (Höjberg et al., 2015). Moreover, monitoring of N concentrations and N transport has been initiated at a monitoring station in the main stream draining the three project areas.

2.1.2.2. EN2. Phosphorus emissions. Phosphorus (P) emissions to surface waters such as lakes in Denmark are an important part of the implementation of the WFD RBMP2, and many lakes have a reduction target set for P loadings under RBMP2 (Ministry of Environment and Food, 2016). Changes in P emissions following the land consolidation in the project areas will be quantified utilising an existing Danish P-index model (Andersen and Kronvang, 2006). The source, mobilisation and transport parameters in the P-index modelling system will be established for a baseline period before land consolidation and a post period based on data from national registers on P inputs and crop type information. Moreover, monitoring of P concentrations and P transport has been initiated at a monitoring station in the main stream draining the three project areas.

2.1.2.3. EN3. Ochre and Sediment pollution. Changes in drainage in the project areas after restoration of streams and surrounding areas may possibly influence the ochre pollution and transport of sediment in streams. Changes in ochre pollution and sediment transport will be quantified by a survey of representative stream channels using the Danish Stream Habitat Index before and after land consolidation and by monitoring of the total iron concentration, the sediment bed load and the suspended sediment load at the established stream monitoring station in the project areas.

2.1.2.4. EN4. Ecological quality. Changes in the physical and ecological quality of streams as an effect of the land consolidation process will be measured and quantified in the project areas, and stream restoration might be included as part of the project. The improvements in physical and ecological quality will be monitored utilising the Danish Stream Habitat Index and the Danish Stream Fauna Index at representative reaches before and after the land consolidation (Baattrup-Pedersen et al., 2004).

2.1.2.5. EN5. Mitigation measures. Implementation of mitigation measures to reduce nitrogen and phosphorus losses from agricultural land such as restored wetlands, constructed wetlands, buffer strip, etc. may be part of the land consolidation process in the project areas by securing areas for such management options. The effects of such mitigation measures will be quantified utilising standard effect rates developed for each mitigation option depending on local conditions (Jensen et al., 2012).

2.1.3. Biodiversity conservation indicators

Biodiversity conservation effects are divided into five indicators that reflect the geographic focus and ecological relevance of the land consolidation.

2.1.3.1. BC1. Localisation focus. The indicator for localisation is based on the reasoning that efforts to increase the conservation benefits in land use within a landscape depend on the current biodiversity values held within the landscape. This principle underlies all designation of protected habitats or reserves (e.g. Anon., 1992) and is based on the reasoning that habitats and species of conservation value must be protected in place as they cannot readily be re-localised to other places. The indicator is quantified using the national Biodiversity Map (Ejrnæs et al., 2014) that assigns a bioscore (1–20) to all terrestrial areas reflecting their potential value as habitat for nationally red-listed species (near threatened, vulnerable and threatened species) using the IUCN criteria for red-listing (IUCN, 2003). The bioscore combines and sums 13 national GIS layers reflecting landscape features and mapped habitats with a statistically significant indicator value for red-listed species with a species score developed from all observations of red-listed species with a geographical precision within 100 m. We evaluate the localisation focus by calculating the mean bioscore (weighted by area) of the project area in consideration for or directly included in a land consolidation. The resulting figure is compared with the mean bioscore of the land authority in charge of the land consolidation process. The indicator is divided into 5 steps: 1 = "below average bioscore of municipality", 2 = "approx. average bioscore", 3 = "above average bioscore, < 50%", 4 = "above average bioscore, < 100%", 5 = "above average bioscore, > 100%".

2.1.3.2. BC2. Protection level. A main issue in biological conservation is protection of habitats and species from negative impacts such as drainage, eutrophication and cultivation but also allowing natural processes such as grazing, flooding, coastal erosion and sand drift. Irrespective of threat, the effective response is a guaranteed level of protection (Chape et al., 2005). We have adjusted the global recommended categories of protected areas (IUCN, 1994) to better reflect our project objectives of evaluating the protection level of small lots scattered in the landscape. We use the following 6-point ranking of protection level:

1. Rotational agricultural fields and built-up areas
2. Extensively cultivated fields and plantations
3. Protected habitats by the Danish Nature Protection Act (semi-natural habitats under extensive farming)
4. Natura2000 habitats under protection by the Birds Directive or Habitats Directive with adaptive management of targeted species and habitats
5. Strictly protected areas designated for biodiversity
6. Part of large nature reserve or national park under strict protection and allowing for natural dynamic processes.

Acknowledging that the value of effective protection increases with the conservation value of an area, we decided to multiply the protection level with the bioscore and to use the area-weighted average of this multiplum as indicator for the protection of biodiversity. The change in the indicator following land consolidation will reflect the degree of biodiversity conservation accomplished.

2.1.3.3. BC3. Spatial continuity. Habitat fragmentation is a well-established threat to species populations and habitat quality (Saunders et al., 1991). When natural ecosystems are broken up into isolated islands of natural vegetation surrounded by urban or cultivated land, remnant populations become small and vulnerable to local extinction and edge effects cause changes in fundamental physico-chemical properties as well as mass effects of invading alien species. The indicator for this property is selected as the mean ratio between the area and the perimeter of all contiguous habitat patches within the project area. We have decided to treat habitat broadly as all land covered by forests or semi-natural vegetation.

2.1.3.4. BC4. Restoration. In most current habitats of the Danish countryside, natural biota and processes have been severely compromised by centuries of cultivation. Typical anthropogenic effects include drainage, planting of crops and commercial trees for timber, weeding out non-target plants, harvesting trees before aging and decomposition, reduction of populations of large herbivores and carnivores as well as control of flooding and coastal erosion. In light of this degradation, restoration may be a relevant measure – not only to create new habitats for colonisation but also to avoid losses of existing habitats and vulnerable populations (Wiens and Hobbs, 2015). We use the increase in area under ecological restoration following land consolidation as indicator for ecological restoration.

2.1.3.5. BC5. Integration in production. Although biodiversity conservation works most effectively in areas designated to natural processes, the integration of wildlife concerns into cultivation practices in forestry and farming may also contribute to habitat opportunities for species with declining populations. Examples include conversion of annual crops to perennial crops, conversion to organic farming and conversion to no-tillage farming. We use as indicator the increase in area where significant improvement in integration of wildlife concerns occurs in response to land consolidation.

2.1.4. Outdoor recreation indicators

Five indicators for recreational effects contribute to the evaluation of the multifunctional land consolidation projects. The indicators measure both the spatial landscape changes that provide potential for recreational use, changes in the levels of public knowledge of the recreational opportunities in the area and, finally, changes in the recreational practices in the area.

2.1.4.1. OR1. Public access. Legal public access to areas comprises a basic condition for recreational use (Morris et al., 2011). In Denmark, legal access possibilities depend on the type land use (Jensen, 2002). The indicator for access can be evaluated by a GIS analysis of the sizes and the spatial distribution of areas with access using existing digital land use/land cover data. However, ground truth data is needed to confirm the analysis. For instance, access to pastures depends on whether they are fenced and grazed by animals or not. The analysis will estimate the relative increase in land with access, including areas made accessible due to synergy with re-allocated areas. It is not possible to include voluntarily granted access in the GIS data, without knowledge of these.

2.1.4.2. OR2. Recreation facilities/trails. Facilities or trails can support recreational usage (Bell, 2007), acknowledging that preferences vary among visitors and are not always in favour of (too many) facilities (Moore and Driver, 2005; Manning, 2011; Pigram and Jenkins, 2006). A land consolidation project may provide potentials for location of new facilities like a parking lot, a shelter, a primitive campsite etc. Evaluation of the indicator depends on further knowledge of aim and plans formulated in the local land consolidation process. A GIS spatial analysis (like in indicator OR1) can be performed based on this information.

2.1.4.3. OR3. Accessibility. Ample literature validates that shorter distance to nature areas or urban green spaces correlates with the number of visits (Hornsten and Fredman, 2000; Toftager et al., 2011; Nielsen and Hansen, 2006). Evaluating recreational effects should therefore include analysing the potential number of people within reach of the areas that have become available for recreational use due to the land consolidation. This can be done by time-distance analysis including, for instance, discrete choice modelling taking substitution issues into account (Zandersen et al., 2007).

2.1.4.4. OR4. User knowledge. Recreational use of the assets within an area depends on the potential visitors' knowledge of the opportunities. There are various factors influencing this knowledge, such authorities and the choice by other parties of platforms to communicate about the recreational opportunities (Bell, 2007). The land consolidation project itself might also increase public awareness of the area. The indicator will measure the public knowledge about places worth visiting before and after the land consolidation project. Public participation GIS (PPGIS) (Fagerholm et al., 2016; Brown et al., 2014) provides a digital- and internet-based platform for collecting data about the user knowledge of specific places.

2.1.4.5. OR5. Recreational use. The actual usage in terms of visits to and around the area represents the most obvious indicator for the recreational effects. However, asking people about their recreational practices implies many methodological considerations (Jensen, 1999): the practices can be evaluated with both qualitative and quantitative methods and may target both people living in and near the consolidation project as well as visitors and tourists. A PPGIS investigation reveals the spatial pattern of recreational visits and activities before and after the land consolidation project.

2.1.5. Indicators for rural development

Applying a rural development perspective in land consolidation projects is not new. Especially in rural areas with a less industrialised agricultural sector, land consolidation is promoted as a planning tool for rural development. The arguments in policy and planning concerned with such rural settings are that a more efficient agriculture would improve the economy for the farmers and prevent them from emigrating and that more efficient farming with a better economy at farm level will create workplaces within branches like, distribution and transport, manufacturing and services. These activities would in general improve the socio-economic situation and create incitements for the rural population not to move out of the area (Huylenbroeck et al., 1996; Zhang et al., 2014; Jürgenson, 2016; Abubakari et al., 2016). Without arguing against such understanding, we suggest that in rural settings with an industrialised agricultural production, land consolidation may contribute to rural development in a slightly different way. Also, rural areas with a highly industrialised agricultural production, as in Denmark, suffer from declining population numbers, derelict houses and loss of public and private services. Recent studies point out that in such settings access to workplaces in the agricultural sector is not an incentive for people to stay or settle in rural communities. Rather people settle in rural Denmark because of the landscape and nature amenities and to be part of the everyday rural life in a smaller community (Johansen and Thuesen, 2011; Johansen and Chandler, 2014; Andersen and Nørgård, 2012). Studies also show that people leave rural areas because of limited access to nature, lack of experience with nature and difficulties in creating a social network and creating a local community identity (Andersen and Nørgård, 2012). In a nutshell, many villages and rural settlements in highly industrialised farming settings are isolated and imprisoned by a monotonous and uniform production landscape created by a highly efficient agricultural sector without nature. Access to villages and rural settlements is by the main roads that are often heavily trafficked by trucks, agricultural machinery and private cars, mostly driven by parents who are transporting themselves and/or their children to school, to work, for a walk with the dog, to visit friends or to the local sports association, because footpaths between neighbouring villages and town centres have disappeared (Johansen et al., 2016). Land consolidation in a highly industrialised agricultural country still needs to apply a rural development perspective; however, attention should be directed at re-creating some of the most important characteristics of not farming-related rural everyday life. Therefore, we suggest that indicators include: community identity, entrepreneurship and quality of everyday rural life. Over time, improvements of these qualitative marks may be reflected in the statistics, including demography and socio-economic factors as well as prices and sales times for houses.

2.1.5.1. RD1: Community identity. Despite the fact that site-based community identities are often historically and long-term culturally anchored, there is evidence that rural communities can be changed and/or strengthened and/or created when increasing public awareness of a special landscape or nature quality/feature.

2.1.5.2. RD2: Entrepreneurship. Historical and cultural rural life styles include an element of entrepreneurship and creativity that is inspired by closeness with nature. Recent studies show the importance of micro-entrepreneurs and life style-based entrepreneurship for rural development (Herslund, 2012; Marsden and Smith, 2005)

2.1.5.3. RD3: Quality of everyday life. Access to nature via local footpaths when going for a walk or taking a shortcut to the grocery store, the sports club, the primary school and/or to visit local friends is an important quality of everyday rural life. Such footpaths may also serve as informal meeting places for the local population. Such meeting places are among the key features for stabilising and creating a common community identity.

2.1.5.4. RD4: Sales times for house. The sales times for houses together with the square meter price show how attractive a particular rural community is compared with other rural communities in the region.

2.1.5.5. RD5: socio-economic and demographic profiles. These profiles provide information about the diversity and dynamics of the community.

2.2. Scores and visualisation

Faced the challenge of evaluating the indicators within and across academic disciplines, the research group decided to score all indicators from 1 to 5 according to the improvements facilitated by multi-functional land consolidation: 1 = negligible improvement, 2 = small improvement, 3 = moderate improvement, 4 = large improvement, 5 = very large improvement. Rather than predicting the process of land consolidation, we score the potential for indicator improvement in the initial phase. During this initial screening phase, indicators may be scored qualitatively based on a combination of expert knowledge, accessible data and pilot field studies. Examples of such data are advertising of houses on real estate platforms on the internet, EU agricultural subsidy applications, occurrence of threatened species, cultivated crops and fertilizer use and the level of recreational response to areas with

Table 1
Summary of data collection divided into disciplines and indicators.

Discipline/indicator	1	2	3	4	5
Farm economics	Data from national maps on soil quality combined with maps of the cropped fields affected by the land consolidation.	Data from national agricultural registers with address point for the farm and maps of the shape and location of the fields. Also road transport with slurry is included based on national registers on slurry production and distribution and agreements for trade with slurry.	Efficient use of agricultural machinery depends on field shapes and sizes and distances to the farm. GIS calculations were conducted using maps of the fields and structural farm data from the national agricultural registers and the farm census.	National maps of environmental regulation and other regulations restraining farmers from full flexible utilisation of agricultural land.	Local information combined with project-specific map-based assessment of land use.
Rural development	Ethnographic field studies. Phone survey. Desk-research on homepages and the news.	Ethnographic field studies. Phone survey. Desk-research on homepages and the news.	Ethnographic field studies. Phone survey. Desk-research on homepages and the news.	Local, regional and national statistics on square meter prices and selling period. Real estate homepages.	Local, regional and national statistics on demography and socio-economy.
Biodiversity conservation	Data on endangered species and proxies for habitat quality.	Data on current level of protection from land registry and area statistics.	Field recording and GIS-calculations of core-periphery of natural areas.	Field observations and expert evaluation of restoration potential.	Field observation and expert evaluation of integration opportunities.
Outdoor recreation	GIS-calculations based on existing maps and mapping of allocated areas.	GIS-calculations based on existing maps and mapping of allocated areas.	GIS-calculations based on existing maps and mapping of allocated areas.	PPGIS-survey with both inhabitants and visitors.	PPGIS-survey with both inhabitants and visitors.
Environmental protection	Data from national registers on farming practices linked to a national nitrogen model. Measurements at a monitoring station of before-after concentrations and loads.	Data from national registers on farming practices linked to a national phosphorus risk map. Measurements at a monitoring station of before and after concentrations and loads.	Measurements at a monitoring station and hydromorphological index before and after.	Survey of hydromorphological index before and after and use of knowledge transfer from similar performed restoration projects.	Knowledge of established measures and use of transfer functions from similar measures investigated.

new public access. Table 1 summarises the different methods for data collection within each of the five disciplines.

For impact evaluation of multi-functionality after completion of land consolidation, we suggest to combine base-line mapping with land use change statistics and monitoring of indicator changes at different scales from plots and fields to properties and landscapes.

As a means of visualisation and presentation, we have used the spider graph enabling an indicator by indicator comparison as well as an aggregation of indicators from each discipline for spider graph evaluation of the multifunctionality across all five disciplines. The aggregation within each discipline comprises the mean score for the values of all five indicators, acknowledging that weighting according to possible differences in the importance of the individual indicators might be considered as an alternative option. Fig. 7 in the result section illustrates the approach using a specific area as an example.

3. Applying our method to a Danish case

In this section, we apply our method by illustrating a suggestion for screening of the potential of multifunctional land consolidation. We have assessed the indicators based on their best-case potential improvement. The illustrative case is the area 'Lønborg Hede', which is one out of three areas in Denmark designated by the Collective Impact working group as pilot project areas for carrying out and evaluating the impact of multifunctional land consolidation. Fig. 2 shows the location of the three areas in Denmark. The circle in bold shows the location of Lønborg Hede.

Lønborg Hede is an area comprising heathland, wetland and coniferous plantations located near the inlet of Ringkøbing Fjord. The main target area for the land consolidation project is shown in Figs. 3 and 4. It consists of a core area dominated by wet and dry heath (brown colours), but partly intertwined and surrounded by coniferous plantations (dark green colours) and fields of cropland (yellow colours). The small villages Lønborg, Vostrup, Hemmet, Sønder Vium and Lyne is located near Lønborg Hede and summer cottages are found along the inlet and the towns of Skjern and Tarm to the north.

3.1. Screening of the potential of multifunctional land consolidation in Lønborg Hede

3.1.1. Farm economics

The dominant soil type in Lønborg Hede is coarse sand, which for a range of crops demands irrigation. As the heath area is poor in nutrients compared with other farm areas and reallocation may potentially have synergies with irrigation infrastructure, the value of the soil quality indicator is high (4). The value of the road transport indicator is low (1) due to limited transportation of manure in the project area. The project area is characterised by relatively large, mainly regularly shaped fields, leading to high utilisation of machinery, which is not likely to decrease (2). The value of the regulation indicator (4) is relatively high because farmers are willing to grow crops further away from protected areas. Flexibility is moderate (3) as the overall land fragmentation in the project area is moderate.

3.1.2. Biodiversity conservation

Lønborg Hede is an obvious *conservation priority* for the municipality as the project area includes important habitats for endangered species and less intensive farmland than the rest of the municipality (4) (Fig. 5). Likewise, there are immediate opportunities for increasing the *protection* level of habitats, given that semi-natural habitats are managed mainly as hunting grounds, streams are managed as drainage canals for the surrounding farmland and coniferous plantations are managed for silvicultural purposes (4). We see a great potential for increasing the *spatial continuity* of important habitats in the area as intensively cultivated fields and coniferous plantations currently cause a conspicuous fragmentation of the core heathland habitats (5). Restoration

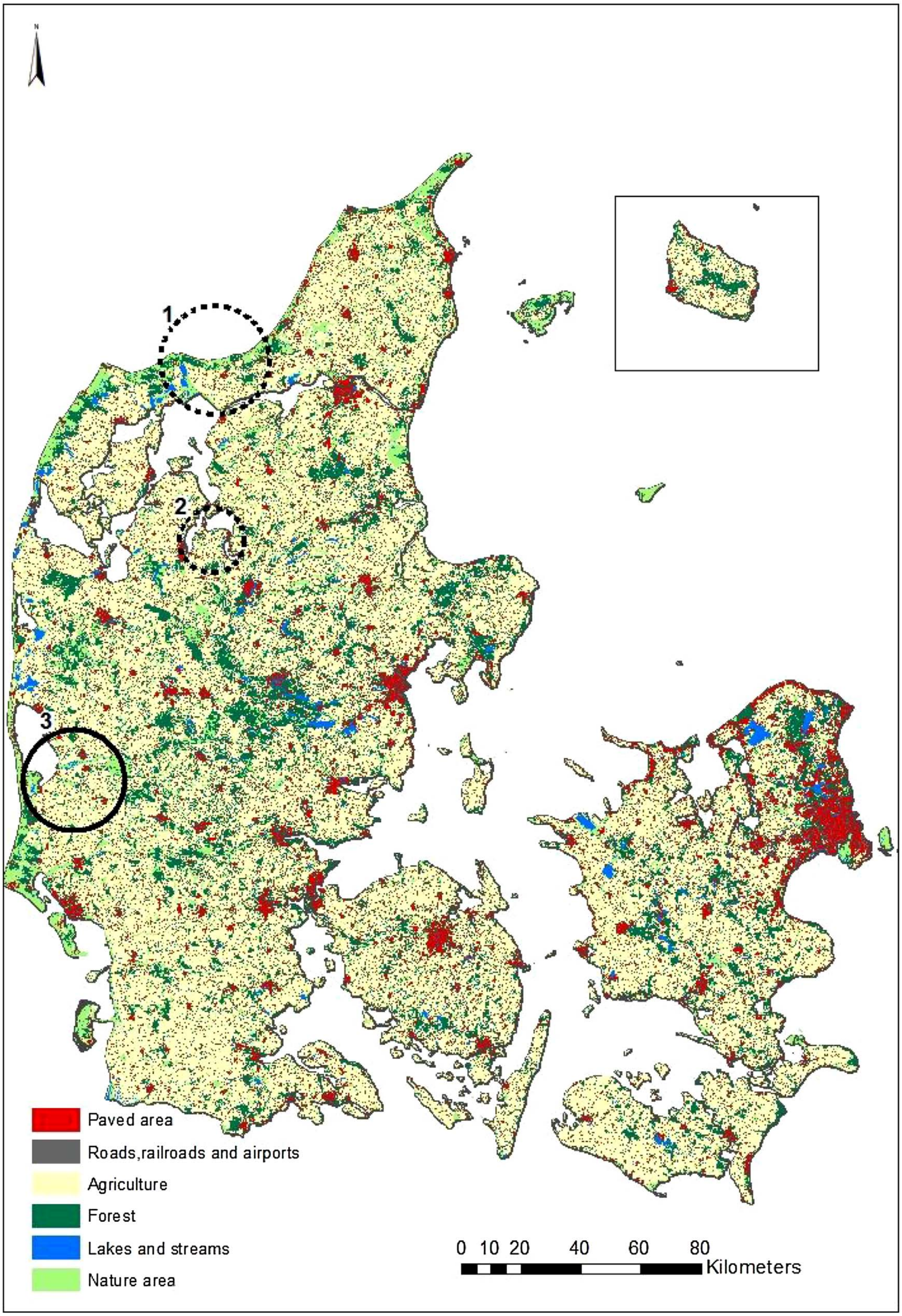

Fig. 2. Location of the three case project areas encompassed by the multifunctional land consolidation project in Denmark. Also shown is the land use divided into six categories and the initially selected case project areas. The 3 project areas are: 1. Part of Jammerbugt Municipality; 2) Nordfjends in Skive Municipality; 3) Lønborg Hede and surrounding areas in Ringkøbing-Skjern Municipality.

opportunities are evident and include hydrological restoration, restoration of grazing as a process and restoration of natural vegetation after conversion of farmland and plantations (5). Opportunities for integration include in particular extensive meat production from near-natural grazing of cattle, horses and deer, but also recreation and hunting (4).

Fig. 3. Arial photo showing the main target area for the land consolidation project (white outline) and the location of surrounding urban zones, villages and areas with summer cottages (grey polygon/black outline).

3.1.3. Environmental protection

Nitrogen (N) has been chosen as one of the key indicators of the impacts of land consolidation on the environment as the pilot area in Ringkøbing-Skjern municipality (Lønborg Hede) selected for testing the multi-functionality of land consolidation has several sensitive water bodies mapped under the EU Nitrates Directive and the EU Water Framework Directive (WFD) (5) (Table 2). Therefore, the changes in N leaching as a result of the land consolidation are believed to be of local benefit for the implemented two EU Directives. A baseline annual climate-normalised nitrate (N) leaching estimate was calculated utilising the Danish consensus leaching model 'NLES4′. National register data on crop types and farm nutrient balances registered every year on a field block scale (ca. 8 ha) was used as input data for the model together with regional statistics on harvest, climate, etc. Baseline annual climate-normalised N leaching at field scale for the pilot area in the Lønborg Hede area amounts to ca. 70 kg N ha^{-1} (see Fig. 6).

The difference in annual climate-normalised N leaching from before to after land consolidation for each pilot area will therefore be the result for N of the land consolidation process. Another, more direct, effect of monitoring the results for N leaching in the land consolidation process was the establishment of a stream monitoring station in spring 2016 in a first order stream draining the pilot area (see Fig. 6).

Phosphorus emissions from agricultural areas are of less importance than N for the water quality and ecological status of water bodies in the project area (2). The current hydro-morphological and ecological quality of a smaller stream draining the project area is poor according to the WFD categories and there is, therefore, a great possibility for improving both the hydro-morphological and ecological quality of the stream as part of the project (5). The over-deepened and unstable stream channel draining the project area causes release of ferrous iron from pyrite in the soil, and this precipitates as ochre in the stream channel and creates a high sediment input to the channel. Both ochre and sediment act as a pressure on stream ecological quality, which may decline if the stream channel is restored following the project, providing an elevated stream bed and increased groundwater table in the area (4). Lastly, implementation of targeted mitigation measures such as re-establishing of riparian wetlands is a project option that should be further investigated (4).

3.1.4. Outdoor recreation

If initial aims are fulfilled, the land consolidation project will improve the amount of land with public access, not mainly through new areas with access but also by connecting existing recreational areas as well as providing potential locations for new outdoor recreation facilities and trails. The score is therefore high (4) for these indicators. Today, public access to nature in the area of Lønborg Hede is quite low (2) as the distance to villages and urban areas as well as to areas with secondary houses/tourism infrastructure is relatively long, taking into account competing alternative recreational opportunities in the River Skjern Valley and along the Ringkøbing Fjord. The initial investigations revealed that the local residents are not strongly attached to Lønborg Hede or aware of its recreational values. The land consolidation project has a strong potential for significantly increasing such awareness (4) but due to the many alternatives and its low accessibility the potential use of the area is moderate (3).

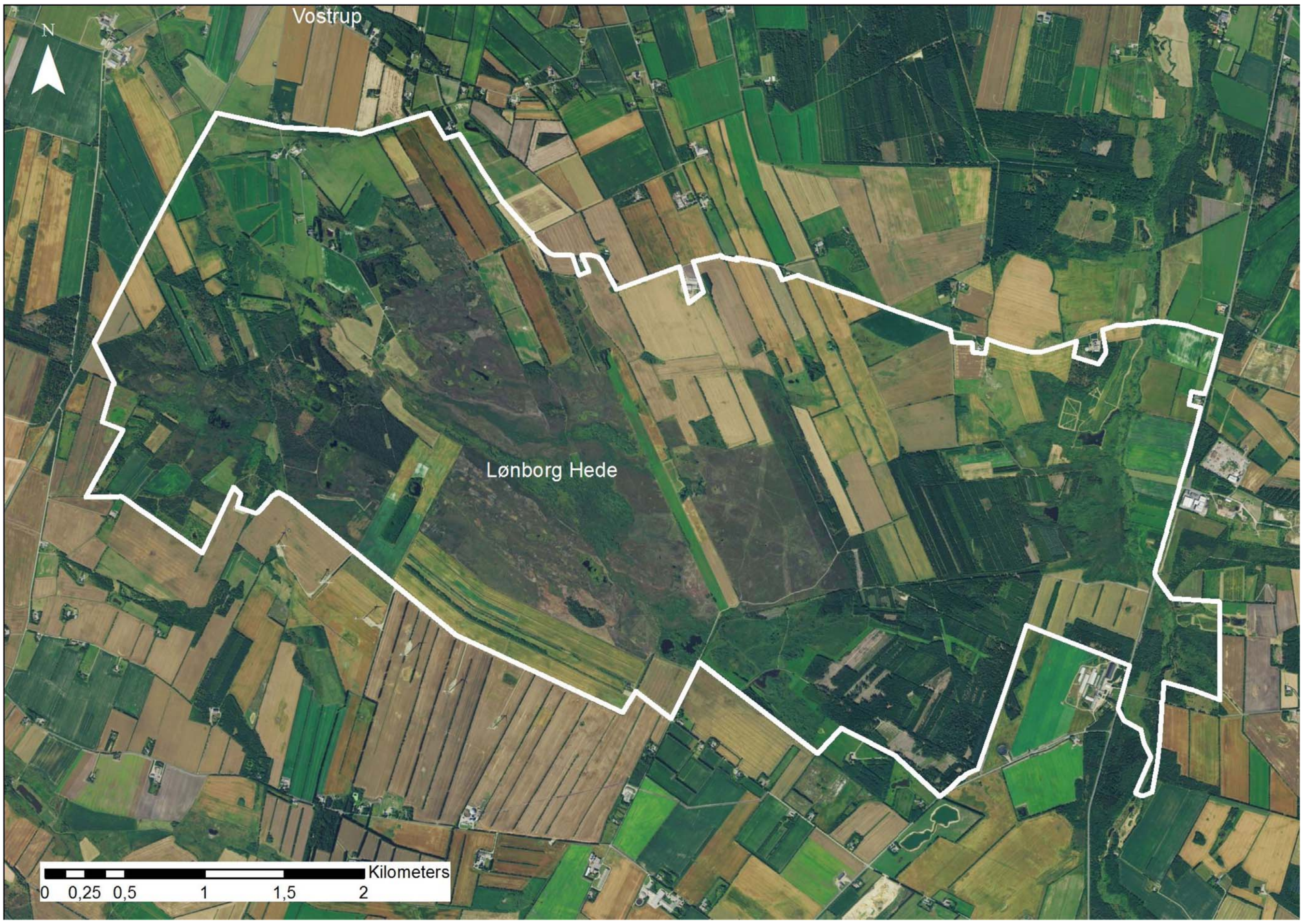

Fig. 4. The target area for land consolidation (white outline) consists of a central area dominated by heathland and a mosaic of coniferous plantations and fields planted primarily with spring barley.

3.1.5. *Rural development*

RD1 *Community identity*. Informal interviews with local people engaged in rural development pointed at a lack of community spirit in the five smaller villages surrounding Lønborg Hede and in and between two of the villages there was a tendency to disagreement and distrust between different resident groups. The desk-research and a pilot field work revealed only few local community activities. The heath landscape of Lønborg Hede is unique compared with its neighbouring areas that encompass fjord, sea and rivers areas. The five residential communities are located around the heath. The score for community identity is four as multifunctional land consolidation, with focus on landscape quality, will expectedly lead to a new community identity (4). RD2 *Entrepreneurship*. Some of the smaller farms close to Lønborg Hede have already established small-scale production of special products. Thus, entrepreneurship scores two because there is potential for entrepreneurship within outdoor activities, for example horse riding,

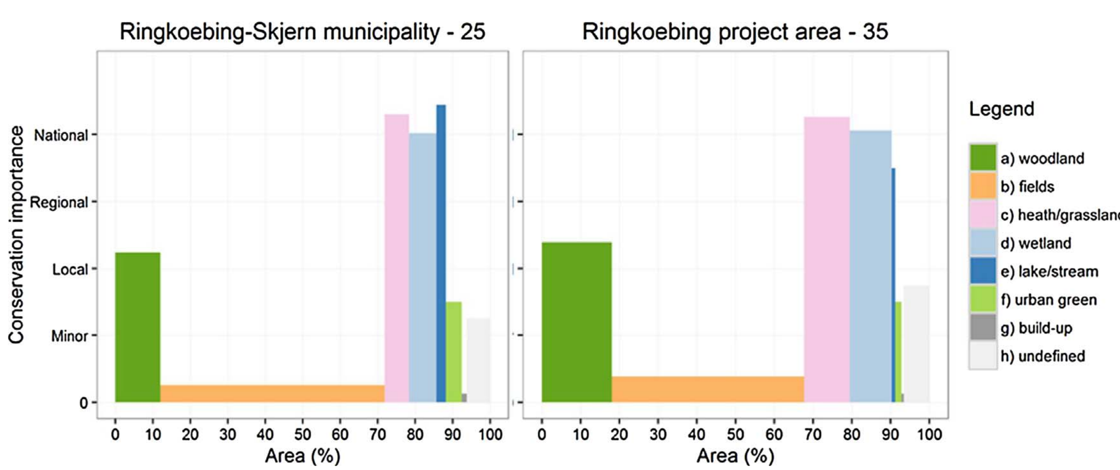

Fig. 5. Localisation focus (BC1): Natural Capital Index for the whole of Ringkøbing-Skjern municipality (NKI = 25) and for the designated project area Lønborg Hede (NKI = 35). NKI reflects the relative area proportions of main habitats and their value as habitat for endangered species and the increase from municipality to project area reflects the focus on biodiversity.

Table 2
Nitrogen sensitive groundwater and surface water bodies within the three pilot areas.

Pilot area	Sensitive groundwater bodies (EU Nitrates Directive)	Sensitive surface water bodies (EU Water Framework Directive)	Plan for reductions of nitrogen to sensitive surface water bodies under the Water Framework Directive
Lønborg	N vulnerable groundwater aquifer	Ringkøbing estuary	1422 ton N reduction (35%)

and for community (social) entrepreneurship like grazing guild, and experiments with new local crops may also take place (2). RD3 *Quality of everyday* life. Access to nature via local footpaths is rather limited in Lønborg Hede and so is the number of informal meeting places for local interaction. A score of five is given because of the potential for linking the villages with minor footpaths or trails through the heath landscape (5). RD4 *House prices* and RD5 *Socio-economic profile* are both given score (3) as the area has some of the lowest square meter prices for houses in Denmark and a rather large share of elderly people. This may change over time by a strengthened local identity, stronger cooperation between villages and improved access to nature via local footpaths. Potential barriers may be that the area is scarcely populated as well as the state and location of the houses.

3.2. The results visualised

The results are visualised in the spider graphs in Fig. 7. The central graph shows the aggregated values as the mean value for the five indicators for each of the five disciplines. These individual indicators are shown in the five surrounding graphs. The aggregated graph reveals a project area with large potential for biodiversity and conservation followed by environmental protection, moderate potential for improving recreation and rural development and low potential for improving farm economics. More nuances appear when inspecting the variations among the disciplinary graphs, which reveal, for example, a high potential for improving life quality and public access.

4. Discussion and conclusion

The case illustrates how an inter-disciplinary approach solidly anchored in different academic disciplines may transcend the perspective of perceiving land consolidation as farm level re-organisation with the aim to increasing productivity. Thus, our approach is interdisciplinary and involves farm level, community level, municipality level and society level and thereby provides important input to the Collective Impact working, strengthening cooperation and allowing local stakeholders to adjust the existing allocation of land.

Our investigation indicates that land consolidation may be a powerful tool to overcome transition problems and ecological degradation of rural areas, as argued by Huylenbroeck et al. (1996). Moreover, our interdisciplinary method for screening of land for land consolidation is not only an evaluation tool but may also serve as a planning tool by identifying relevant groups of local actors to participate in the process. Additionally, it emphasises the need for cross-sector cooperation, as

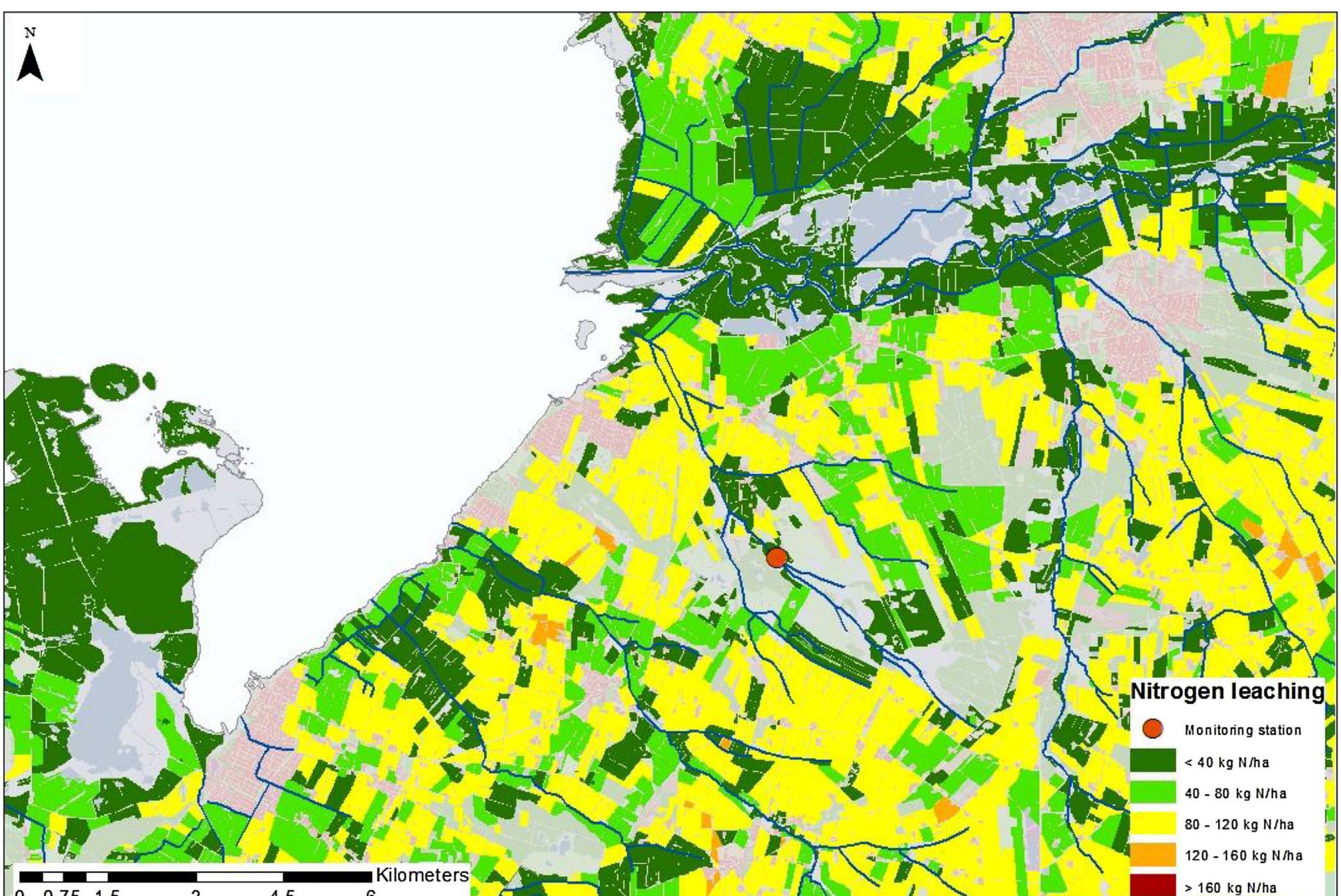

Fig. 6. Map showing annual climate-normalized nitrate leaching from the root zone on agricultural land in the pilot area Lønborg Hede in Ringkøbing-Skjern Municipality with streams and a nutrient monitoring station in Styg Brook.

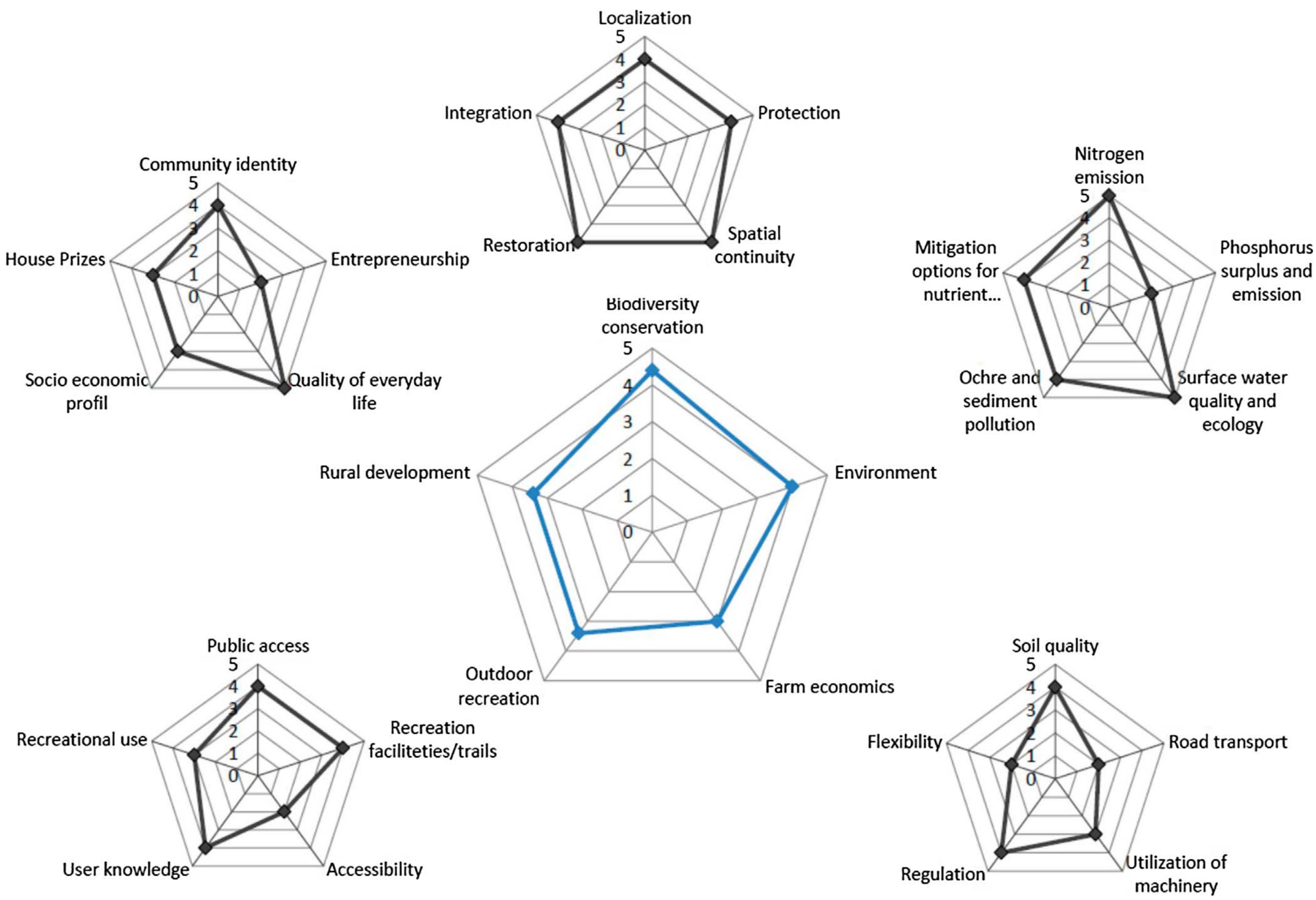

Fig. 7. Spider graphs of the potential disciplinary multifunctionality and the interdisciplinary multifunctionality of multifunctional land consolidation in Lønborg Hede.

argued also by Zhang et al. (2014).

Our approach includes five academic disciplines, and the five indicators chosen within each discipline illustrate the complexity embedded in multifunctional land consolidation. Miranda et al. (2005) reached a similar conclusion whilst also calling for a better method for screening. We suggest that the 25 indicators and multiple methods for measuring and evaluating these, although complex, may serve as such a planning tool.

In addition, based on the illustrative case study, we argue that the spider web is a tool that explains the indicators in simple terms, both disciplinarily and interdisciplinarily, and that it thereby may facilitate the communication between different groups of actors, including farmers, researchers, experts, planners and rural community agents. The aggregate indicator offers a fast perspective in the relative potential of many functions and may be used not only to prioritise but also to draw attention to overlooked aspects of the land consolidation process. In this perspective, our method may be a useful tool in a collaborative discourse (Healey, 1997) on land consolidation including the Collective Impact framework. It has the potential to provide shared measurement as input to the continuing communication and mutual activities as well as establishing a common agenda (see Fig. 1).

Land consolidation is often used as an approach to support authorities in need of effective local implementation of high-level decisions, for instance the building of important infrastructure such as roads and bridges or the realisation of major restoration projects Hartvigsen, 2014. In this case, the initiative comes from a national board with NGOs representing stakeholders, including land owner interests, committed to the idea of collective impact. The real project owner is, however, the municipality with no prior agreement about collective commitment between project owners, landowners and public interests. This situation calls for an approach with public involvement and a collaborative rationality (Innes and Booher, 2016) from an early phase. In a neo-endogenous rural development perspective, the choice of using the land consolidation tool might rather have grown from within. In a Danish context such growth may anchored in a local development plan or a Local Action Group initiative. We suggest that the development of evidence-based indicators by researchers that are external to the political process may serve not only the purpose of prioritization but also communication and discussion among decision makers, among public authorities across sectors and among local rural people engaged in community development. Along this line of thinking, the indicators are developed to reflect the best of all worlds without paying attention to the existing political climate. It should also be noticed that all five disciplines represent aspects of the common good, i.e. societal interests in sustainable use of land for provision of all commodities from food to health, leisure, development, environment and biodiversity. We suggest that the project owner (here the municipality) will use the indicators in the process of negotiating between competing and sometimes conflicting interests and as a tool to identify a common agenda and shared measurement. The common agenda might not always serve all the functions reflected in the indicators. However, the use of the indicator tool will force the actors to consider multifunctional dimensions during the collaborative process.

Our method is a method in progress. The indicators for functions have been used to inspire the local discussion for finding a common agenda for the land consolidation project in the Lønborg Hede area. The indicators served as point of departure for debating both specific initiatives and overall trajectories of local development. However, one relevant angle yet to be explored more thoroughly is a matrix for the mapping of synergies and conflicts between different functions (see e.g.

Willemen et al., 2010) and the respective disciplinary scores in Fig. 7. For example, focusing on protecting and improving the condition for a specific species as an element of biodiversity conversation may bring synergy to strengthening the local identity, while too much focus on creating outdoor recreation for tourists may weaken the quality of everyday life for the local residents. Another example of a dynamic interplay is the environmental regulation and application of nitrogen on agricultural fields where land consolidation is likely to shift the location of intensive farming, thus affecting the nitrogen losses at a local aggregate level. Such a matrix may find inspiration from the Millennium Ecosystem Assessment (2005) and/or in the "Framework for understanding the sustainable development goal interactions" (International Council for Science, 2016) and further strengthen the use of the method in planning and negotiating of multifunctional land consolidation projects.

Our case is based on interpretations made at an early stage of the land consolidation project in Lønborg Hede. The potentials revealed in Fig. 7 will be further qualified/validated by use of the methods shown in Table 1. The measurements and investigations will be repeated when the land consolidation project ceases, expectedly in 2019. A land consolidation project can have both direct and indirect effects. An example of a direct effect is, for instance, if landscape structures become accessible for public recreation activities due to a redistributed pattern of ownership. This could imply new areas and/or corridors with public access but also synergy with existing recreational infrastructures. Furthermore, the time factor is essential regarding indicators such as ecological restoration where natural species and dynamics might take many decades to colonise and establish (Eriksson et al., 2002). The direct effects may be negative for some indicators and positive for others depending on the new pattern of land ownership. The indirect effects include potentials that are only fulfilled when the land consolidation is combined with other initiatives, actions or agreements. Again using recreation as example, the land consolidation could provide space for building a shelter for hikers etc., but building the shelter depends on means than the land allocation. Also indirect effects could emerge from the multifunctional land consolidation process. Participation and dialogue between local actors might improve recreational opportunities because people start to communicate, discuss ideas and enter into voluntary agreements and action as illustrated in the Collective Impact approach in Fig. 1. It follows that evaluation of the effects of a land consolidation project using the proposed indicators is not straightforward: some indicators are easily measured upon the closure of the land consolidation process, while other indicators represent potentials that eventually will be fulfilled, sometimes conditional on accompanying means and actions. As an example, changes in nitrogen emissions to protected groundwater aquifers and the vulnerable Ringkøbing estuary can be modelled and thus documented based on the recorded changes in land use and agricultural practices in the project area where a national consensus leaching model is applied (Kronvang et al., 2008; Hinsby et al., 2012). Factors to consider are delays in the nitrogen response in groundwater (c.f. Howden et al., 2011) as well as possible project-induced changes in surface water nitrogen retention due to restoration of the stream channel, and hence the natural hydrology, in Lønborg Hede and other spinoff wetland restoration programmes implemented along the stream corridor towards the Ringkøbing estuary (Windolf et al., 2016). Another, and more straightforward method to document the outcome of the project, is pre and post land consolidation monitoring of stream water quality at a station measuring changes in nitrogen, phosphorus, sediment and iron concentrations and loads.

According to a survey of land consolidation projects in selected European countries (Vitikainen, 2004), the projects cover a wide range of objectives, ranging from improving agricultural productivity to landscape and nature preservation and regional development. In this respect, the Danish land consolidation project does not cover new ground (e.g. see Hiironen and Riekkinen, 2016; Crecente et al., 2002). However, the collective impact approach appears novel as previous land consolidation projects have been carried out following a formal planning process and s pre-defined (political) objectives. In this respect, the experiences from the citizen-based process of formulating the objectives and the formal learning in terms of a research-based evaluation of the effects can contribute to develop the concept of land consolidation in order to facilitate the solving of complex land use processes. The aim of this paper was to introduce an interdisciplinary method for screening and evaluating potential areas for multifunctional land consolidation. Our method was applied in a Danish pilot project on multifunctional land consolidation and comprised scoring of 25 indicators selected to inform about the potential for sustainable development within five areas of public concern for rural development. These were farm economics, outdoor recreation, biodiversity conservation, rural community development and environmental protection. We found that our method is a useful tool for identifying land for multifunctional land consolidation, that it may facilitate the involvement of new actors in the planning and that it may support the collaborative planning discourse and a Collective Impact.

References

Abubakari, Z., van der, Molen P., Bennet, R.M., Kuusaana, E.D., 2016. Land consolidation, customary lands, and Ghana's Northern Savannah Ecological Zone: an evaluation of the possibilities and pitfalls. Land Use Policy 54, 386–398.

Andersen, H.E., Kronvang, B., 2006. Modifying and evaluating a P index for Denmark. Water Air Soil Pollut. 174, 341–353.

Andersen, H.S., Nørgård, H., 2012. Motives for moving to rural peripheral areas – work 'rural idyll' or 'income transfer'. Geoforum Perspektiv 11 (22), 32–44.

Aubry, C., Ramamonjisoa, J., Dabat, M.-H., Rakotoarisoa, J., Rakotondraibe, J., Rabeharisoa, L., 2012. Urban agriculture and land use in cities: an approach with the multi-functionality and sustainability concepts in the case of Antananarivo (Madagascar). Land Use Policy 29, 429–439.

Baattrup-Pedersen, A., Friberg, N., Pedersen, M.L., Skriver, J., Kronvang, B., Larsen, S.E., 2004. Anvendelse af Vandrammedirektivet i danske vandløb, vol. 499 Danmarks Miljøundersøgelser, Aarhus Universitet. Faglig rapport fra DMU.

Bell, S., 2007. Design for Outdoor Recreation. Taylor & Francis Group, London.

Brandt, J., Vejre, H., 2004. Multifunctional landscapes – motives, concept and perspectives. In: Brandt, J., Vejre, H. (Eds.), Multifunctional Landscapes, Theory, Values and History I. WIT Press, Southampton, pp. 3–31.

Brown, G., Kelly, M., Whitall, D., 2014. Which public? Sampling effects in public participation GIS (PPGIS) and volunteered geographic information (VGI) systems for public lands management. J. Environ. Plann. Manag. 57 (2), 190–214.

Carvalho-Ribeiro, S.M., O'Riordan, A.L.T., 2010. Multifunctional forest management in Northern Portugal: moving from scenarios to governance for sustainable development. Land Use Policy 27, 1111–1122.

Chape, S., Harrison, J., Spalding, M., Lysenko, I., 2005. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. Phil. Trans. R. Soc. B: Biol. Sci. 360, 443–455.

Costanza, R., et al., 1997. The value of the world's ecosystem services and natural capital. Nature 387 (6630), 253–260.

Crecente, R., Alvareza, C., Urbano, F., 2002. Economic, social and environmental impact of land consolidation in Galicia. Land Use Policy 19, 135–147.

de Groot, R.S., Wilson, M.A., Boumans, R.M., 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecol. Econ. 41 (3), 393–408.

Ejrnæs, R., Petersen, A.H., Bladt, J., Bruun, H.H., Moeslund, J.E., Wiberg-Larsen, P., Rahbek, C., 2014. Biodiversitetskort for Danmark. Udviklet i samarbejde mellem Center for Makroøkologi, Evolution og Klima på Københavns Universitet og Institut for Bioscience ved Aarhus Universitet. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 96 s. – Videnskabelig rapport fra DCE – Nationalt Center for Miljø og Energi nr. 112.

Eriksson, O., Cousins, S.A., Bruun, H.H., 2002. Land-use history and fragmentation of traditionally managed grasslands in Scandinavia. J. Veg. Sci. 13 (5), 743–748.

Fagerholm, N., et al., 2016. Assessing linkages between ecosystem services, land-use and well-being in an agroforestry landscape using public participation GIS. Appl. Geogr. 74, 30–46.

Højberg, A.L., Windolf, J., Børgesen, C.D., Troldborg, L., Tornbjerg, H., Blicher-Mathiesen, G., Kronvang, B., Thodsen, H., Erntsen, V., 2015, National kvælstofmodel. Oplandsmodel til belastning og virkemidler: Metoderapport. De Nationale Geologiske Undersøgelser for Danmark og Grønland – GEUS.

Haldrup, N.O., 2015. Agreement based land consolidation − In perspective of new modes of governance. Land Use Policy 46, 163–177.

Hartvigsen, M., 2014. Land consolidation and land banking in Denmark – tradition, multi-purpose and perspectives. Danish J. Geoinf. Land Manag. 47 (1), 51–74.

Hartvigsen, M., 2015. Experiences With Land Consolidation and Land Banking in Central and Eastern Europe After 1989. Land Tenure. Food and Agriculture Organization of the United Nations.

Healey, P., 1997. Collaborative Planning: Shaping Places in Fragmented Societies.

Macmillan, London.
Herslund, L., 2012. The rural creative class: counterurbanization and entrepreneurship in the Danish countryside. Sociol. Ruralis 52, 235–255.
Hiironen, J., Riekkinen, K., 2016. Agricultural impacts and profitability of land consolidations. Land Use Policy 55, 309–317.
Hinsby, K., Markager, S., Kronvang, B., Windolf, J., Sonnenborg, T., Thorling, L., 2012. Threshold values and management options for nutrients in a catchment of a temperate estuary with poor ecological status. Hydrol. Earth Syst. Sci. 16 (8), 2663–2683.
Hornsten, L., Fredman, P., 2000. On the distance to recreational forests in Sweden. Landsc. Urban Plann. 51 (1), 1–10.
Howden, N.J.K., Burt, T.P., Mathias, S.A., Worrall, F., Whelan, M.J., 2011. Modelling long-term diffuse nitrate pollution at the catchment scale: data, parameter and epistemic uncertainty. J. Hydrol. 403, 337–351.
Huylenbroeck, G.V., Coelho, C.J., Pinto, P.A., 1996. Evaluation of land consolidation projects (LCPs): a multidisciplinary approach. J. Rural Stud. 12 (3), 297–310.
IUCN, 1994. The World Conservation Union Guidelines for Protected Area Management Categories. IUCN, Gland, Switzerland.
IUCN, 2003. Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version 3.0. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.
Innes, J.E., Booher, D.E., 2016. Planning with Complexity: An Introduction to a Collaborative Rationality for Public Policy. Routledge, London.
International Council for Science, 2016. A Guide to SDG Interactions: From Science to Implementation. International Council for Science, Paris.
Jensen, F.S., 1999. Forest Recreation in Denmark from the 1970 to the 1990. The Research Series No 26. Danish Forest and Landscape Research Institute, Hørsholm.
Jensen, F.S., 2002. The general public's knowledge about the legal rights of access to forest and other nature areas in Denmark. In: Barros, S. (Ed.), UFRO Division 6 Conference. Valdivia, Chile 11–17 November 2002. (1969-182).
Johansen, P.H., Chandler, T., 2014. 68 Landsbyer Fem år Efter. CLF Report 30/2014. University of Southern Denmark.
Johansen, P.H., Thuesen, A., 2011. Det, der betyder noget for livet på landet… – en undersøgelse af positiv landdistriktsudvikling i form af befolkningsfremgang i et landsogn i hver af de fem regioners yderområder. CLF Report 6/2011. University of Southern Denmark.
Johansen, P.H., Jørgensen, A.G., Mærsk, E., Rotbøll Randlev, H., 2016. SMART transport på landet: En undersøgelse af nye transport initiativer, der forbinder land og by og lokalsamfund i landdistrikterne. CLF Report series 54/2016. University of Southern Denmark.
Jongeneel, R.A., Polman, N.B.P., Slange, N.H.G., 2008. Why are Dutch farmers going multifunctional? Land Use Policy 25, 81–94.
Kania, J., Kramer, M., 2011. Collective Impact. Stanford Social Innovation Review. Stanford University, pp. 36–41.
Kronvang, B., Andersen, H.E., Børgesen, C.D., Dalgaard, T., Larsen, S.E., Bøgestrand, J., Blicher-Mathiesen, G., 2008. Effects of policy measures implemented in Denmark on nitrogen pollution of the aquatic environment. Environ. Sci. Policy 144–152.
Latruffe, L., Piet, L., 2014. Does land fragmentation affect farm performance? A case study from Brittany, France. Agric. Syst. 129, 68–80.
Leenen, H., 2014. Land development in The Netherlands. ZfV – Zeitschrift für Geodäesie. Geoinf. Landmanag. 3, 166–172.
Manning, R.E., 2011. Studies in Outdoor Recreation. Search and Research for Satisfaction. Oregon State University Press, Corvallis.
Marsden, T., Smith, E., 2005. Ecological entrepreneurship: sustainable development in local communities through quality food production and local branding. Geoforum 36 (4), 440–451.
Marsden, T., Sonnino, R., 2008. Rural development and the regional state: denying multifunctional agriculture in the UK. J. Rural Stud. 24, 422–431.
Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.
Miranda, D., Crecente, R., Alvarez, M.F., 2005. Land consolidation in inland rural Galicia, N.W. Spain, since 1950: An example of the formulation and use of questions, criteria and indicators for evaluation of rural development policies. Land Use Policy 23, 511–520.
Moore, R.L., Driver, B.L., 2005. Introduction to Outdoor Recreation – Providing and Managing Natural Resource Based Opportunities I. Venture Publishing, Pennsylvania.
Morris, J., O'Brien, E., Ambrose-Oji, B., Lawrence, A., Carter, C., Peace, A., 2011. Access for all? Barriers to accessing woodlands and forests in Britain. Local Environ. 16 (4), 375–396.
Münch, A., Nielsen, S.P.P., Racz, V.J., Hjalager, A., 2016. Towards multifunctionality of rural natural environments?– An economic valuation of the extended buffer zones along Danish rivers, streams and lakes. Land Use Policy 50, 1–16.
Nielsen, T.S., Hansen, K.B., 2006. Nearby nature and green areas encourage outdoor activities and decrease mental stress. CAB Rev. 1 (59).
Olsen, J.V., Bojesen, M.H., Schou, J.S., 2016. Arrondering af landbrugsjord i Danmark. Tidsskrift for Landoekonomi 202 (2), 85–92.
Pigram, J.J., Jenkins, J.M., 2006. Outdoor Redreation Management. Routledge, London.
Plieninger, T., et al., 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. Land Use Policy 33, 118–129.
Pröbstl-Haider, U., 2015. Cultural ecosystem services and their effects on human health and well-being – a cross-disciplinary methodological review. J. Outdoor Recreat. Tour. 10, 1–13.
Saunders, D.A., Hobbs, R.J., Margules, C.R., 1991. Biological consequences of ecosystem fragmentation: a review. Conserv. Biol. 5, 18–32.
Stutter, M.I., Chardon, W.J., Kronvang, B., 2012. Riparian buffer strips as a multifunctional management tool in agricultural landscapes: introduction. J. Environ. Qual. 41, 297–303.
Toftager, M., et al., 2011. Distance to green space and physical activity: a Danish national representative survey. J. Phys. Act. Health 8 (6), 741–749.
Vejre, H., Jensen, F.S., Thorsen, B.J., 2010. Demonstrating the importance of intangible ecosystem services from peri-urban landscapes. Ecol. Complex. 7 (3), 338–348.
Vitikainen, A., 2004. An overview of land consolidation in europe. Nord. J. Survey. Real Estate Res. 1, 2004.
Wiens, J.A., Hobbs, R.J., 2015. Integrating conservation and restoration in a changing world. BioScience 65 (3), 302–312.
Willemen, L., Hein, L., van Mensvoort, M.E.F., Verburg, P.H., 2010. Space for people, plants, and livestock? Quantifying interactions among multiple landscape functions in a Dutch rural region. Ecol. Indic. 10, 62–73.
Windolf, J., Tornbjerg, H., Hoffmann, C.C., Poulsen, J.R., Blicher-Mathiesen, G., Kronvang, B., 2016. Successful reduction of diffuse nitrogen emissions at catchment scale: example from the pilot River Odense, Denmark. Water Sci. Technol. 73 (11), 2583–2589.
Zandersen, M., Termansen, M., Jensen, F.S., 2007. Evaluating approaches to predict recreation values of new forest sites. J. For. Econ. 13 (2–3), 103–128.
Zhang, Z., Zhao, W., Gu, X., 2014. Changes resulting from a land consolidation project (LCP) and its resource-environment effects: a case-study in Tianmen City of Hubei Province, China. Land Use Policy 40, 74–82.