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Forest land consolidation and its effect on climate

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ABSTRACT

Land use changes and forests both play an important role in combating climate change. The climate effects of forest land consolidation have, however, not been studied in detail. As such, this study identifies a number of possible climate effects of forest land consolidation. To specify these, the increased carbon storage in the Pahkakoski land consolidation project (Finland) due to increased forest growth is valued through substitution costs. The results show that the value of the increased carbon storage in the project area is approximately 750 000 euros, or €153/ha. This emanates from the increased growth due to remedial drainage and from the increased forested area. The result is, however, sensitive to changes in the shadow price of carbon. Likewise, the study recognises a need for studies concerning the total climate effect of measures, such as remedial drainage that may also release carbon from the ground. While the overall effects of forest land consolidation are difficult to estimate with current knowledge, this article highlights the potential of land consolidation to combat climate change.

1. Introduction

Combating climate change is a top priority for the European Union (EU). Europe is looking for ways to substantially reduce its greenhouse gas emissions, while encouraging other nations and regions to follow suit. Concurrently, the EU is developing a strategy for adapting to the impacts of climate change that can no longer be prevented. (EC, 2011). Climate change presents challenges across a broad spectrum of human activities. In this regard, the surveyor's skills have particular application in several areas. Although the largest source of carbon emissions is derived from fossil fuels, it is followed by changes in land use — the latter stemming predominantly from the conversion of forests to agriculture. According to Boateng et al. (2014), land use is responsible for more than 30% of all greenhouse gas emissions. Changes in land use (such as reforestation) can, thus, be of particular importance in mitigating climate change, both by lowering emissions and by reducing greenhouse gases in the atmosphere. The UN programmes (REDD and REDD+) aim to reduce greenhouse gas emissions from deforestation and forest degradation by planting 40 000 km^2 of forests to partly compensate for the 130 000 km^2 that is cleared annually (comprising 20% of the world's greenhouse gas emissions). REDD has identified above ground carbon storage in forests as the most feasible carbon pool to conserve (Barnes and Quail, 2011).

While approximately 22% of forests worldwide are reserved for personal use and/or owned by communities and indigenous groups, governments still control the large majority of forested areas. A commitment to effective forest management planning can help mitigate some of the negative impacts of poor stewardship. (Barnes and Quail, 2009). Better systems for valuing and pricing forest resources to include their environmental and carbon mitigation functions also have important roles to play in safeguarding forests as stores of carbon and in reducing carbon emissions (Quan and Dyer, 2008).

Finland is the most forested country in the European Union: 86% of the land area is classified as forestry land. 60% of these lands are privately owned. Most privately owned forests are of small or medium size, with an average size of 30 ha. (Finnish Statistical Yearbook of Forestry, 2013). Over the years, these privately owned family forests have been divided into smaller properties, mainly as a result of inheritance. In some parts of Finland, this has culminated in parcels that are long and narrow, which impede their use for timber production. In forest land consolidation projects, long and narrow forest parcels are reshaped closer to square shapes, and the forest road and drainage networks are maintained or expanded. The reshaping of land parcels, among other effects, decreases boundary areas and therefore increases the forest area (Airaksinen et al., 2007; Kolis et al., 2014). Additionally, the improvement of drainage networks increases the growth of trees (Sarkkola et al., 2012). These

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increases in the total tree volume mean that forest land consolidation increases the carbon storage in the forests.

Land use change, predominantly stemming from the conversion of forests to agriculture, remains a large contributor to carbon emissions. This indicates that there exists a strong hypothesis that if and when the total volume of trees in the forest is increased through forest land consolidation, the increased forest area and tree growth will expand stores of carbon and thereby reduce carbon emissions. But as no valuation methods exist to assess the monetary effect of this increased storage, the importance of the climate effect of forest land consolidation may be under- or overestimated.

The traditional effects of forest land consolidation, such as reduced harvesting costs, can be defined in monetary terms quite easily (see Kolis et al., 2015). However, as the objectives of land consolidation have become more complex (see Vitikainen, 2004, p. 28–29) so has the decision-making process. Land management strategies might not be optimal for the mitigation of climate change. In our opinion, in addition to direct market-based values, other benefits and drawbacks, such as environmental effects, should be taken into consideration, especially at the stages when financing and allocation of funds are considered (Hiironen et al., 2010). One aspect that has garnered little attention in analyses so far is the climate effects of forest land consolidation.

This study is designed to estimate the monetary value of the reduced emissions to the atmosphere due to increased carbon storage. Thus, this raises the main question of this study: what is the net present value (NPV) of the increased carbon stock achieved by forest land consolidation? In order to solve this question, the case study estimates, based on previous studies, how much the forest land consolidation expanded carbon storage due to the increased area for forestry and growth of trees.

This paper aims to analyse and monetise climate impacts in forest land consolidations. More generally, the contribution of this paper is to demonstrate how to monetise environmental impacts. The paper sets out to assist strategy planners to choose the best and the most cost-effective tools to mitigate climate change in the context of land management.

Section 1 introduced the background and objectives of the study. As forest land consolidation is not a typical land management tool worldwide, the subsequent section also promotes the concept by presenting its basic premise and expected results. As such, Section 2 identifies the potential climate effects of forest land consolidation. Section 3 focuses then on the study material (3.1) and on the methodology of the study (3.2). Sub-section 3.1.1 presents the basic information (e.g. location and property structure, proceeding, and achieved results) on the forest land consolidation project in Pahkakoski. The section also reveals, based on previous studies, the increase in forestry area and the growth of trees in the case area. Shadow prices for the related CO_2 emissions are defined in sub-section 3.1.2. Sub-section 3.2 describes how a substitute cost method was utilised to calculate the monetary value of these changes. Section 4 presents the results of these calculations. Partial sensitivity analysis where one input variable is changed at a time is presented together with the results. Finally, the discussion and conclusions are presented in Section 5.

2. Forest land consolidation

Land consolidation of forested areas may be carried out as a separate project, or as part of a project that covers both agricultural and forest areas. In most countries, the focus here is on farmland consolidation, but forest land consolidation is also conducted in some countries, either on the side of farmland consolidation (e.g. Finland and Germany) or even merely on forestland (e.g. Sweden) (Vitikainen, 2004). Forest land consolidation may focus on improving the shape and ownership of properties as in Sweden, or combine land rearrangement with road construction, improvements to drainage, and building facilities for recreation, as in Finland and Germany.

The main goal of forest land consolidation is often to improve the usability of the area for commercial forestry, but depending on the country and the location, environmental issues may also be important. Hinz (2013) divides the benefits of German forest land consolidation projects into five different categories: 1) benefits to the forest economy, 2) benefits to ownership and legal security, 3) benefits to recreation and cultural values, 4) benefits to the environment, and 5) social benefits, e.g. increased employment and safety.

A precondition of forest land consolidation is often that the benefits exceed the costs of the project. There are some differences as to which benefits are counted: in Sweden and Finland, the focus is on the monetary benefits to the forest owner and harvest costs (Airaksinen et al., 2007; Lantmäteriet 2012), while German studies often include a wide range of environmental and societal benefits (Mosiek et al., 2007; Hinz 2012)

The typical effects of forest land consolidation include lower harvest costs, higher prices paid for timber, shorter borders, and larger forest stands through the improved shape of properties and better road access (Lantmäteriet, 2012; Hinz, 2013; Kolis et al., 2014). These goals are reached through combining scattered parcels, improving the shape of parcels, arranging fragmented ownership, and creating protected areas. Afforestation can also be carried out in connection with forest land consolidation projects or separately, for example, to improve water protection (cf. Hinz, 2012; Hartvigsen, 2014); however, this is not a goal in highly forested countries, such as Sweden and Finland.

2.1. Climate effects of forest land consolidation

German studies on forest land consolidation include the most detailed analysis of climate effects. By contrast, Finnish studies on forest land consolidation do not mention climate effects (Airaksinen et al., 2007; Honkanen 2008; Kolis et al., 2015), while a Swedish study mentions them briefly without attempting to monetise (Toresson and Bransell, 2008). For Germany, Hinz (2012) includes benefits to climate change, but due to a lack of relevant studies on the topic, the study only includes a calculation of the benefits of using land consolidation for preparing the forest for a changed climate.

Based on the aforementioned studies, and on the climate effects of forestry, it can be concluded that forest land consolidation may affect the climate in various ways. In particular, this occurs through: 1) drainage works, 2) increased forested area, 3) increased maintenance and growth of forests, and 4) decreased transportation distances.

The first three factors increase carbon storage in the area through an increased forest biomass (cf. Kolis et al., 2015), while the last factor decreases fuel consumption. For most of these, the overall effect on carbon is difficult to estimate, because the same measure may increase carbon emissions through some processes, while also decreasing carbon emissions through other processes. The net effect of these factors varies between sites and studies, and the carbon balance of a single drained forest site may, for example, be positive or negative over time (e.g. Lohila et al., 2011; Simola et al., 2012; Ojanen, 2014).

Draining peatland leads to peat decomposition, which leads to a loss of carbon in the soil over time (Simola et al., 2012). However, the change in carbon stock due to peat decomposition from drainage of previously drained forests remains unclear. In these cases, the peatland has already previously lost peat and may continue to do so, while part of this is taken up by the biomass. What