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Landowners' willingness to promote bioenergy production on wasteland – future impact on land use of cutaway peatlands

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ABSTRACT

Landowners are the key players in bioenergy production on wasteland; such as cutaway peatlands. In this study, the landowner's interest to use cutaway peatlands for bioenergy production was investigated using a survey and GIS (Geographic Information Systems) methods in an area in South Ostrobothnia, Finland. The focus was to identify which different bioenergy production chains are preferred by the respondents: combustion, gasification or biogas production from agriculture, energy-willow short-rotation forestry or forestry based energy crops. Also, the influence of personal environmental values on the selection was measured and the future impacts and barriers for the land use were assessed.

Afforestation was the most popular after-use method among the landowners. The next most favorable method was energy crop cultivation but it was highly dependent on economic profitability and subsidies. Currently, approximately 8.2% or 500 ha of the total peat extraction area could be used for bioenergy production in the region by 2035. Based on the survey, forest based biomass is the best option if bioenergy is to be produced. The next choice was agro biomass and the least favored plant was willow. This study suggests that the biggest cutaway peatlands will be converted to forest energy in the future. Suggestive results were that the owners with high environmental values are especially interested in agro biomass growing and the landowner having a distant home place does not have a negative influence on bioenergy production. Altogether, land use and biomass production of cutaway peatlands is connected with the demands of the Finnish bio-economy.

1. Introduction

In literature there has been a debate concerning land use planning and bioenergy production targets (Gamborg et al., 2012; Scarlat et al., 2013). The fundamental concern has been the effect of energy crops on land use and food prices; because the growing of energy plants for 1st generation biofuels has taken space from food production and increased food prices. In developing countries especially, this has been considered to have a negative socio-economic impact (Edrisi and Abhilash, 2016). Consequently, bioenergy production is increasingly conducted on marginal lands globally, to avoid competition with food production and to increase the sustainability aspect of bioenergy production (e.g. Xue et al., 2016; Stoof et al., 2015; Abolina et al., 2015).

The term "marginal land" has multiple definitions: the land can be economically barely profitable for agriculture purposes or it is not in commercial use. Marginal land can also be considered as "idle, under-utilized, barren, inaccessible, degraded, excess or abandoned lands, lands occupied by politically and economically marginalized populations or land with characteristics that make a particular use unsustainable or inappropriate" as defined in Dale et al. (2010). Wasteland is one form of marginal land. The definition of wasteland is also contradictory and environment dependent, but in this study wasteland is considered as a patch of land having no appreciable vegetative cover and degraded by natural as well as anthropogenic activities (as presented in Edrisi and Abhilash 2016; Oxford Dictionary, 2016).

Peat extraction lands, common in Finland as well as in Sweden, Ireland and the Baltic countries, can be specified as wasteland after peat extraction. Peat is a commonly used fuel especially in Finland and Ireland, where about 5–7% of primary energy consumption relies on peat. Peat is used as agricultural and horticultural purposes as well (World Energy Council, 2013). At the beginning of the peat extraction, the pristine mire is dried with ditches and the surface layer (vegetation and partially decomposed organic matter) is removed. After ca. 20–30 years of peat extraction, the area is left bare without vegetation. E.g. in Finland, about 2500 ha of peat extraction areas is shifting to cutaway phase annually (Leupold 2004; Salo and Savolainen 2008). Cutaway

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peatlands suit well the definition of wasteland because the pristine mire is modified and left barren by anthropogenic action. Even though the area can be considered as wasteland, the surface is usually barren or untapped only for a relatively short time (max. a few years), because it is recommended that a profitable after-use method is applied as soon as possible. However, the transition from barren surface to vegetative cover can vary greatly, depending on soil properties (Leupold 2004). Natural vegetation succession is a very slow process on cutaway peatlands (Huopalainen et al. 1998; Silvan and Hytönen 2016).

In Northern Europe, the cutaway peatlands have been identified as a potential wasteland to grow energy crops, such as: willow, reed canary grass (RCG), and forest energy (Leupold 2004; Pahkala et al., 2005; Picken 2006; Parviainen 2007; Salo and Savolainen 2008; Järveoja et al., 2013; Jylhä et al., 2015). However, a relatively small amount of cutaway peatland is suitable for energy crop production because there are challenges related to water level, remote locations, site nutrition, the size of the released area, landowner's interests and ignorance which can have a negative impact concerning bioenergy production. According to Picken (2006) about 26–42% of these areas are suitable for agricultural use and 57% for afforestation, based on the mineral subsoil characteristics. However, the poor nutrition is often a challenge on cutaway peatlands. Especially, phosphorus and potassium are limited nutrients. The nutrition can be improved by soil preparation, fertilization, and mixing of the bottom peat with the underlying mineral soil (Leupold 2004; Huotari et al., 2006; Salo and Savolainen 2008; Huotari et al., 2009).Nowadays, the most popular form of after-use is afforestation, but there are several other after-use methods available, such as: agriculture, tourism, restoration, and bird sanctuary (Leupold 2004; Salo and Savolainen 2008). If the bioenergy after-use method is chosen, then special attention must be paid to the location, since the transportation distance of biomass to a biomass utilization plant has a significant effect on the net energy yield. The cost-effective transportation distance is dependent on a variety of factors, such as: plant species, type of transportation method and bioenergy conversion technology. E.g. in the case of reed canary grass (RCG, *Phalaris arundinacea*) which is harvested in spring time for combustion, the highest economically transportation distance to a combustion plant is roughly 70–80 km (Lötjönen and Knuuttila 2009). If the distance is higher, the transportation costs are usually too high to achieve a feasible production chain.

Currently, peat extraction covers almost 1000 km^2 area in Finland and the most intensive extraction area is situated in the western parts of Finland (Laasasenaho et al., 2016). The status of peat as a natural resource is contradictory, because it has many environmental impacts. Peat extraction usually causes: deterioration of peatland habitats and biodiversity, hydrological problems, emissions into waterways, and increased greenhouse gas emissions (e.g. Mäkiranta et al., 2007). However, the extraction is regulated by Finnish Environmental regulation (Ministry of Environment, 2015). On the other hand, peat extraction can be a significant employer in rural areas. The conflict between economy and conservation of nature in peatland utilization has been studied (e.g. Chapman et al., 2003; Tolvanen et al., 2013). There are always trade-offs involved between services the ecosystem provides (clean air and water, flood protection etc.) and economical goals in peatland and people's opinions are highly dependent on a person's background, such as: home location (city or countryside) and education (Tolvanen et al., 2013). An inquiry, clarifying the attitude of local inhabitants towards different after-use methods (North Ostrobothnia region, Finland; Kittamaa and Tolvanen, 2013) indicates that the most favored after-use method is forestry or a bird sanctuary/wetland and the second favorable choice is agriculture or energy crop cultivation, whereas the least wanted after-use form is pasture or special plant tillage. The remarkable thing is that 52% of the local people highlighted recreational after-use choices in the study. Similar results about the popularity of afforestation and agriculture have been collected amongst the landowners of the peat extraction areas in Alavus, South Ostrobothnia, Finland (Karjala 2014). Consequently, because of a lack of studies concerning the landowners' background and their environmental opinions as well as their personal motivation versus their chosen after-use method, more studies were needed concerning landowners' interests.

Landowners' opinions towards bioenergy production on abandoned farm land has been investigated, e.g., in Latvia (concerning the growth of short rotation woody crops; Abolina and Luzadis, 2015). There, one of the biggest barriers for the utilization of abandoned farm land is the fact that the landowners do not live near the areas. In another study conducted in Michigan, USA, energy crop growing on marginal lands is limited by trade-offs between farmland availability and marginal land and only one third of the landowners were willing to rent their marginal lands at the rental rates offered (Hayden, 2014). In Finland, as well as in Sweden and in Canada, the peat extraction area is usually located on private or public land (Leupold, 2004). The peat producing company can own the peatland or it can rent the mires. When the peat is exhausted, the area is passed to the after-use phase and the landowner can decide the after-use method. Therefore, the landowner is the key player when the after-use methods are planned. Consequently, the objective of this study was to make a survey of the landowners of peat extraction areas and combine the data collected with geographical information systems (GIS) to recognize the spatial distribution of the potential bioenergy production areas. The main goal was also to improve the knowledge of landowner derived bioenergy after-use methods on cutaway peatlands and future impacts on land use within them.

2. Material and methods

2.1. The study area

The study was conducted in the "Kuudestaan" region, Finland (Fig. 1). The region is one of the European Union's (EU) Rural Development Action Groups located in Western Finland (Erkkilä and Ahonpää, 2014) and the area was chosen because there is intensive peat extraction nationally (Laasasenaho et al., 2016). The municipalities in the area are Alavus, Kuortane, Soini and Ähtäri. There are in total approximately 25,000 inhabitants in the area whose size is 3119 km^2. Economic life is strongly based on forestry and agriculture (Erkkilä and Ahonpää, 2014) and thousands of hectares of peat extraction areas will become wastelands in the area in the near future. Mires and peat extraction intensity in the area is presented in Table 1.

2.2. Search for potential peat extraction areas and landowners

In this study, GIS based methods were used to recognize landowners and potential cutaway peatlands in the "Kuudestaan" region. At first, all the peat extraction areas in the "Kuudestaan" region and all the property or estate codes located within the area were checked using Paikkatietoikkuna web service which contains maps from the National Land Survey of Finland (NLS) (Paikkatietoikkuna, 2016). The estate code was accepted if there were at least 15 ha of peat extraction land within the landowner's property. The area limitation was based on an assumption of reasonable bioenergy production size by after-use experts from a national bioenergy company (personal communication by Ari Laukkanen, Kimmo Aho and Juha Kinnunen on the 12th of January 2016). The size of the areas was calculated by using the Finnish Topographic database and using the "Measure an area on the map" tool. The data on the map was from the year 2014.

Because peat extraction areas are usually situated in remote locations (Salo and Savolainen, 2008), only the most potential areas were then chosen. This meant that the peat extraction areas and landowners within a 10 km radius (by Euclidean distance, personal communication by Ari Laukkanen, Kimmo Aho and Juha Kinnunen on the 12th of January 2016) from the center of the municipality or local farms (from middle sized to big farms having more than a 50-head of cattle, 500 poultry, 30 horses or 500 pigs) were identified. The farm size and