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Research paper

Regional socio-economic impacts of intensive forest management, a CGE approach

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ABSTRACT

The demand for and supply of forest biomass have both been increasing in recent years, which will set new requirements for forest management. Thus, new studies on regionally suitable forest management regimes to fulfill the needs of potential new investments and the impacts on wood supply potential on regional socio-economic welfare are called for. The aim of this study was to examine the impacts of intensive forest management due to increased demand for wood biomass, from the regional economy point of view. In particular, the impact of intensive forest management on 1) regional gross domestic product (GDP), 2) private consumption, and 3) employment were assessed. The study was carried out by using computable general equilibrium (CGE) modelling combined with the requisite statistics and simulation of regional forest potential in the future. The results showed that total regional forest biomass supply with more intensive forest management could be increased annually on average by 26% (1.7 Mm^3) by 2030 compared to the business as usual (BAU) scenario. In this study, regional demand was increased by a hypothetical saw mill (0.5 Mm^3) and biorefinery (0.7 Mm^3). Total regional socio-economic benefits could be 2.8% (€150 M) for GDP, 1.5% (€49 M) for private consumption and 1.6% (780 person-years) for employment, larger by 2030 than in the BAU scenario including multiplier effects. The study demonstrated how much regional socio-economic welfare would increase if regional wood demand with new investments combined with more intensive forest management and wood supply had more attention paid to it.

1. Introduction

Forests in Finland have an important economic and ecological role, which implies that sustainable management of the forests is a desirable goal. Further, sustainable use of natural resources to mitigate climate change is one of the biggest challenges globally [1]. Tackling climate change requires the changes at both regional and global levels. Sustainable forest management also has a significant role in regional development as a part of other rural sectors [2]. The energy supply sector has been the biggest source of greenhouse gas (GHG) emissions (35%, 2010) with the fastest growth (47%) between 2000 and 2010 [3]. Recently, regional analyses have been used to find socio-economically renewable energy production, for instance in western Finland [4], in Brazilian ethanol production [5] and for the energy-efficiency of households in Spain [6]. Regional socio-economic analysis, however, requires not only the statistical information but also in-depth sector-wise knowledge of the area. In this study, we introduce a regional socio-economic analysis by utilizing combined method of CGE modelling with forest management simulations.

Need for the industrial round wood and energy wood has been increasing due to recent investments in the forest industry and energy sectors [7]. In Finland, the volume of round wood harvested domestically was 58.5 Mm^3 in 2015 [7], whereas the aim is for this to increase to 80 Mm^3 by 2025 [8]. In addition, the Finnish national energy and climate strategy aims to use 13.5 Mm^3 (i.e., 27 TWh) forest-based chips in heat and power production by 2020 [9]. In 2015, 8.0 Mm^3 of forest fuels were consumed in heat and power plants (7.3 Mm^3) and in small buildings (0.7 Mm^3) [10]. Small-diameter wood was the most used forest fuel (3.9 Mm^3). Forest fuel usage was growing rapidly from 2000, but since 2010 the use has been declined. Energy wood can complement

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industrial round wood procurement and forest management when the operations are linked together, but industrial round wood can be solely used for energy purposes if there are no other industrial uses. The development of the forest biomass value chain should be seen as integrating industrial and energy wood supply chains [11]. Wood procurement has been targeted at getting more and cheaper logging residues from final cuttings. However, the integrated harvesting of industrial round wood and energy wood from dense young stands has been shown to be a feasible stand management alternative [12]. Forest management simulations [12–14] have been used to analyse forest biomass potentials at stand level, and the results have shown the cost-effectiveness of the use of wood from dense young stands for energy. The profitability of using the first thinning removal either for industrial round wood, energy wood or both is mainly dependent on the price difference between energy wood and pulpwood.

The availability of energy wood has been studied at the national level in Finland by using GIS-based methodology [15–18]. In addition, several energy wood potential studies have been carried out at the regional level [19–23]. In Finland, the potential of small-diameter energy wood has been estimated to vary between 6.2 and 10.4 Mm^3 depending on harvesting method, whereas the potential of logging residues (4.0–6.6 Mm^3) and stumps (1.5–2.5 Mm^3) has been estimated as being much lower depending on annual cutting levels [17]. However, based on the results of a range of studies, there is a large variation in energy wood availability in Finland especially for final cutting removals. For example, according to Nivala et al. [18], the technical energy-wood potential varied between 6.2 and 8.3 Mm^3 for small-diameter wood, 6.6–11.6 Mm^3 for logging residues, and 7.1–12.0 Mm^3 for stumps, when the maximum technical energy wood potential from final cuttings is based on the maximum sustainable level.

The differences between the studies on energy wood potential are usually dependent on the restrictions set for the different types of potential definitions. Energy wood estimates are usually presented for either theoretical potential [24], technical potential [16–18], or economic and ecological potential, all using different restrictions. Practical energy-wood potential can be estimated when utilizing forest owners' willingness to supply energy wood [25,26]. For example, a study of forest owner willingness to supply energy wood at the South Savo region showed that small-diameter energy wood (76–81% of forest owners are willing to sell it) and logging residues (76%) are favored by forest owners, whereas stumps are not (51%) [26]. The ability to pay for energy wood and price elasticities based on supply and demand of energy wood could be applied in the availability analysis. Further, the energy wood use and price development are affected by many external factors, such as the price development of emission allowances and electricity [27].

For assessing the welfare impacts of intensive forest management on a regional economy, we applied computable general equilibrium (CGE) modelling. Contrast to traditional input-output (I-O) models [e.g. Ref. [28]], CGE modelling incorporates an endogenous demand and price system, substitutability in production and demand, optimization of agent behaviour, factor scarcity, and a distinctively more detailed treatment of institutions and the macroeconomic environment [29]. The principal data source for a CGE model is use and supply tables of the national accounting, coupled with additional data on employment, consumption, taxation and transfers. Technically, the CGE model is a system of linear and non-linear equations describing the utility maximizing behaviour of consumers, profit maximizing of the producers and equilibrium conditions and constraints imposed by the economic environment. Then, the equations are solved simultaneously within suitable programming tools such as the GEMPACK or GAMS software packages [29–31]. Having solved the model for the initial period to replicate a particular year (a benchmark) in the past, a dynamic baseline growth path (business-*as*-usual) of the economy needs to be simulated in the model in order to be able to compare other scenarios related to reduced timber supply due to pest infestation, for example [32]. In brief, a CGE model is a mathematical presentation of the economy, from a household to a country, even to the entire world economy, enabling an assessment of welfare impacts associated with scenarios and/or policies [33,34].

Traditionally, CGE models have been used to study international trade, taxes and economic policy packages [35]. More recently, CGE models have been applied to study forest sector policies as well. For instance, Wiebelt [36] studied how macroeconomic policies affect forest resource use in Brazil, Alavalapati et al. [37] analysed distributional effects of an increase in the stumpage price in Canada; Gan [38] studied the potential impacts of forest certification on welfare and trade patterns; Das et al. [39] analysed the economic effects associated with environmental regulations and technical changes in the US forestry sector and Stenberg and Siriwardana [40] examined the economic effects of selective logging, stumpage prices and set-aside areas on the Philippine economy. Most recently, CGE models have been applied to assess climate change mitigation policies [for an exhaustive review, see Ref. [34]], forest-based carbon sequestration policy [41] and the economic impacts of pest infestation [32]. However, there are few (if any) CGE articles tackling the economic potential of intensive forest management. Our study is an attempt to fill this gap.

South Savo is one of the more important regions for forest biomass supply in Finland with a share of about 10% of total harvesting supply [7]. However, the local use of industrial pulpwood is low, because pulp mills are situated in neighbouring regions. Therefore, over half of the forest biomass is used outside the region. In 2016, the industrial round wood demand of South Savo was 2.7 Mm^3 and energy wood demand was 0.4 Mm^3, whereas the volume of harvested round wood was 6.9 Mm^3 and energy wood 0.5 Mm^3 [7]. The regional aim of South Savo is to increase total forest biomass supply to 8 Mm^3 and regional demand to 4 Mm^3 by 2020. The regional target for energy-wood demand has been set to 1.0 Mm^3 by 2020 [42]. Regional wood demand investments have been discussed publicly by increasing the use of pine logs by a new sawmill and energy wood by a biorefinery (biocoal pellet factory). Further, the regional analysis of South Savo showed that the total technical potential varies between 1.9 and 2.8 Mm^3, of which small-diameter wood fluctuates between 0.4 and 0.7 Mm^3, logging residues between 0.7 and 1.0 Mm^3 and stumps between 0.7 and 1.1 Mm^3 [18]. Correspondingly, Anttila et al. [17] have assessed the delimbed energy wood potential as being 0.5 Mm^3, whole trees 0.7 Mm^3, and integrated cutting of small-diameter wood 0.4 Mm^3, but the averages of logging residues (0.6 Mm^3) and stumps (0.3 Mm^3) were much lower than those estimated by Nivala et al. [18].

In the short term, wood supply potential could be increased by intensifying thinnings, conducting fertilizations mainly on mineral soils, executing ditch network maintenance (DNM) on peatlands and scheduling final cuttings according to recommendations, or even bringing forward the final cuttings. In addition, silviculture could also be modified to increase wood supply in the longer run. In this study, we constructed a forest management entity which aimed to producing the required amount of round wood for both the new sawmill and biorefinery planned for construction in the South Savo region in eastern Finland. In practice, this resulted in considerably more intensive forest management than there has been in recent years in the region. The South Savo region was selected as a case study because it represents one of the important forest biomass supply areas in Finland due to the existing forest structure [43] and wood export volumes [7]. The aim of the study was to examine the impacts of this intensive forest management (due to increased demand for round wood) from the regional economy point of view. The impacts on 1) regional GDP, 2) private consumption, and 3) employment were of primary interest.