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GIS based agricultural land availability assessment for the establishment of short rotation woody crops in Latvia

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ABSTRACT

This study provides a country level estimate of geographically available agricultural land area which has been out of production for more than two years and has not been converted into forest or urban area, and is suitable for short rotation woody crop (SRWC) production to meet EU 2020 renewable energy targets in Latvia. Geographic information system (GIS) was used to estimate the total amount and location of agricultural land suitable for SRWC. Several criteria of restrictions were applied in the assessment process, such as agricultural land use status, soil and slope restrictions, designated territories of protection, minimum size of agricultural land within each tax parcel and minimum tax parcel distance from the roads. A total estimated amount of agricultural land that meets the minimum criteria is 261,710 ha. Most (42%) of the suitable agricultural land for SRWC is in the range from 10 to 50 ha. The greatest proportion (29%) of that land is located in the Latgale region. If only 5% (13,085 ha) of the estimated agricultural land were used for SRWC with yields of 7–10 Mg_{dry} ha^{-1} yr^{-1}, it could produce 485,475–693,532 MWh of biomass energy annually, which is roughly 412,653–589,502 MWh of delivered energy if the heating systems are 85% energy efficient. It would result in 13–18% of the total heat energy produced by heating plants in Latvia in 2012.

1. Introduction

In 2009 the European Commission committed to increasing the amount of energy from renewable sources to 20% by year 2020, of which mandatory 10% should be dedicated towards the transport sector [1]. To meet these renewable energy targets in the EU and to produce biomass domestically, it would require a minimum of 10 million ha of land [2]. With the global concerns over agricultural land availability for food production and conservation, there has been great emphasis towards the use of abandoned, marginal, low-productivity, degraded, surplus or other open land for biomass production that does not compete with food production or conservation objectives [3–5]. Abandoned farmlands and/or other still productive agricultural lands that have been out of production for at least two years and have not been converted into forest or urban areas are highly regarded as the potential areas for bioenergy

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production in terms of land quality and productive capacity [4,5]. Due to agricultural land abandonment in many Central and Eastern Europe (CEE) countries, including Latvia [6], surplus agricultural land could become available for bioenergy production without compromising food production.

With the availability of GIS based data, there have been a number of studies done involving spatial analysis of land availability for bioenergy production [e.g. Refs. [7–9]]. The purpose of this study is to provide GIS based country level estimate of geographically available agricultural lands, which have been out of production for more than 2 years, have not been converted into forest or urban areas, and are suitable for SRWC production in Latvia. This study however, does not include social, economic or technology related factors, such as land owner attitudes and their values, potential markets or availability of biomass facilities for SRWC utilization.

2. Materials and methods

2.1. Description of the study area

Agricultural land availability estimates were done for the entire country of Latvia. Latvia covers 64,589 sq km and is situated in North-Eastern Europe with its coastline along the Baltic Sea and bordering countries of Estonia, Lithuania, Russia and Belarus. There are 5 planning regions, 109 municipalities and 9 major cities in Latvia, with a total population of 2.3 million (Fig. 1) [10].

The total amount of agricultural land in Latvia is 2.4 million hectares (ha) and constitutes 37.6% of the total land use [11]. The most recent estimates of 2010 and 2011 on agricultural land use in Latvia, suggest 13–16% (312,000–369,000 ha) of agricultural land being either unmanaged, overgrown or under construction for extended period of time exceeding 2 years [12]. Agricultural land here includes arable land, orchards, grasslands and pasture [13]. Five classes of Agricultural Land Use Status (ALUS) have been established by the Rural Support Service (RSS) in Latvia to identify the various levels of agricultural land management, i.e. (1) managed, (2) unmanaged, (3) overgrown (with shrubs), (4) under construction, (5) managed, but is not classified as agricultural land [12]. The five classes of ALUS were used in this study to identify the potentially available agricultural lands for SRWC production. Of those, class (2) unmanaged and class (3) overgrown were considered most suitable for the establishment of SRWC in Latvia.

2.2. Criteria and data sources

The following criteria of restrictions were applied in the assessment process to determine the amount of geographically suitable and potentially available agricultural land for the production of SRWC in Latvia (Table 1).

2.3. Tools and procedure

GIS was used as a major tool for data analysis and land availability estimates for SRWC production. Spatial analysis was done using ArcGIS, ArcCatalog and ArcMap software version 10 [19]. Geo-spatial data allowed for various factors to be incorporated in the assessment, such as land cover type, parcel size, soil types and characteristics, slope restrictions, vicinity to major infrastructures (i.e. roads) and certain policy restrictions for agricultural land use in the protected territories.

Agricultural land availability for SRWC production was estimated using the data sets and criteria outlined in Table 1 and Fig. 2. The first step was to select tax parcels containing only unmanaged and overgrown agricultural lands from the 2010 RSS ALUS data set [12]. The layers from the first step, consisting of the desired types of unmanaged and overgrown parcels, were joined with the FAO DSMW data set to identify the soil type and slope in each parcel [15]. Since soil types and slopes met the minimum criteria for the establishment of

Fig. 1 – Five major regions in Latvia.

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