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POSSIBILITIES TO IDENTIFY ORGANIC SOILS IN THE AGRICULTURAL AREA IN LATVIA

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Abstract. Organic soils are the soils being rich in organic matter; they comprise part of the utilised agricultural area (UAA) and are a significant source of greenhouse gas (GHG) emissions from agriculture in Latvia. In Latvia, annual precipitation is greater than evaporation, which creates favourable conditions for the formation of soils rich in organic matter. Therefore, the overall **aim of the present research** is to examine possibilities to identify organic soils in the agricultural area in Latvia. To achieve the aim, the following specific **research tasks are** defined: 1) to analyse the agricultural land area in Latvia; 2) to describe the possibilities to identify organic soils in the agricultural area in Latvia and to examine the organic soil area in Latvia. The research found that the UAA, according to various information sources, was different, which made the identification of the organic soil area problematic. Information on soils in Latvia is not collected according to Intergovernmental Panel on Climate Change (IPCC) standards and definitions, therefore the present research classified organic soils according to the latest list of soils in Latvia and IPCC criteria. An analysis of the soil map of Latvia and the available data of the Rural Support Service's Geographic Information System showed that the organic soil area in Latvia was in the range from 148 069 ha to 345 844 ha.

Key words: utilised agricultural land, organic soils.
JEL code: O13; Q15; Q18.

Introduction

Organic soils are the soils being rich in organic matter – plant and animal residues at various stages of decay, organism cells and tissues as well as organism synthesis substances. The IPCC (2006; 2013) explains that a soil is considered to be organic if it meets Criteria 1 and 2 or 1 and 3, which are described below: 1) Criterion 1: the soil layer rich in organic substances is at least 10 cm thickness, the content of organic carbon in a 20 cm topsoil layer is, on average, at least 12 %; 2) Criterion 2: if the soil has never been saturated with water for more than a few days and the content of organic carbon in the topsoil layer rich in organic substances is at least 20 % (content of organic substances is at least 35 %); 3) Criterion 3: if the soil is periodically saturated with water: a) the content of organic carbon in the soil layer rich in organic substances is at least 12 % and the soil has no clay particles; b) the content of organic carbon in the soil layer rich in organic substances is at least 18 % and the content of clay particles in the soil is at least 60 %; c) according to a linear regression equation, the content of clay particles in the soil is in the range of 0-60 %.

In addition to the above-mentioned criteria, an organic soil, unlike mineral soils, is characterised by: 1) lower density and porosity; 2) soil hydraulic conductivity (i.e. the amount of water that can infiltrate into the soil) depends of the degree of decomposition of organic substances; 3) greater capacity for exchange of cations; 4) plant nutrients are bound up in an unavailable organic form to plants.

Organic soils usually form in areas where the decomposition of organic substances is hindered by low air temperatures (boreal climate) or long-lasting humidity (wet climate), as wet soils are short of oxygen that is necessary for the decomposition of organic substances; for this reason, the organic substances accumulate. The spread of organic soils in the world is well characterised by global organic carbon stocks and quantities showing that the key areas in the world where organic soils are available are boreal (temperate) climate and tropical wet climate zones (Grave R.A. et al.,

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2018; Zhang Y., Hadden D., Grelle A., 2017; Batjes N.H., 2016; Peignea J., Viana J.Fr., Payeta V., Saby N.P.A., 2018).

In the agricultural context in Europe, organic soils account for an insignificant proportion of the total utilised agricultural area, yet they are a very significant source of greenhouse gas (GHG) emissions (Hadden D., Grelle A., 2017). Latvia is situated in the temperate climate zone, and organic soils formed here mostly in the soils with a high moisture level, e.g. in wetlands of various types: bogs, wet and overflowing meadows and forests, as well as in valleys and lowlands with a high groundwater level.

If converting wetlands and other wet areas that have a thick organic matter layer into agricultural land, carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions increase owing to increased soil mineralisation, while methane (CH_4) emissions decrease, compared with natural wetlands where no soil drainage and tillage are done (Maljanen et al., 2010; Oleszczuk et al., 2008). Furthermore, unlike mineral soil, organic soils are a permanent source of CO_2 emissions, as organic decomposition processes occur in the soils (Maljanen et al., 2010). This process can significantly affect global carbon (C) stocks if it occurs on a large scale (Kochy et al., 2015; Lenerts A., Popluga D., 2016; Lenerts, A., Berzins, G., Popluga, D. (2016).

In Latvia, annual precipitation exceeds annual evaporation on average by 250 mm and more, which creates favourable conditions for the formation of soils rich in organic matter. A.Karklins (2016a) points out that in Latvia, such soils most often form under too wet conditions – water inflow to a particular area is smaller than water outflow from the area (evaporation, natural drainage); for this reason, the decomposition and mineralisation of plant residues is incomplete, and the soils accumulate partly humified organic matter. Under the climatic conditions in Latvia, such soils form in areas that have (or had) a naturally high groundwater level, the areas periodically overflow or the subsoil layer is quite impermeable to water. Therefore, the overall **aim of the present research** is to examine possibilities to identify organic soils in the agricultural area in Latvia. To achieve the aim, the following specific **research tasks are defined**: 1) to analyse the agricultural land area in Latvia; 2) to describe the possibilities to identify organic soils in the agricultural area in Latvia and to examine the organic soil area in Latvia.

Methodology and data. Analysis, synthesis, the logical construction method, the induction and deduction methods were employed to execute the research tasks. Scientific literature review was used as well. The present research used the results of a research project conducted in 2017 "Assessment of the Contribution of Organic Soils to Agriculture in Latvia – an Assessment of Multifactor Effects for Effective Land Use Solutions" regarding the organic soil area in Latvia (Latvia University..., 2017). To analyse the utilised agricultural area, the present research used information provided by the following national institutions: the State Land Service (SLS), the Central Statistical Bureau (CSB) and the Rural Support Service (RSS). The research also used the data collected by the RSS's Geographic Information System and the digital version of a large-scale soil map (1:10000) to identify the possible area of organic soils.

Research results and discussion

1. Agricultural land area in Latvia

Various sources of information provide different data on the agricultural land area in Latvia. This could be explained, to a great extent, by differences in the definitions used.

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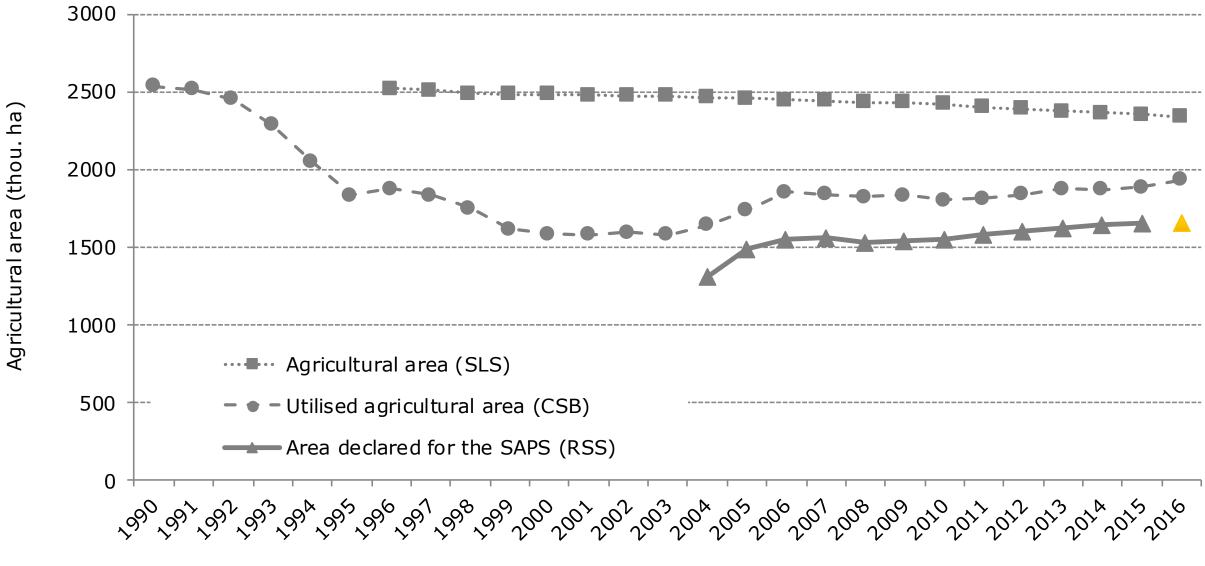
The SLS (2013) provides information on the UAA in accordance with Regulation of the Cabinet of the Republic of Latvia No. 562 "Regulations regarding the Procedure of Classification of Land Uses and Criteria for the Identification thereof" (2007). According to the SLS, the term "agricultural area" refers to the following land uses (classified according to the physical characteristics of land): arable land, orchards, meadows and pastures. These are the data of administrative nature on land uses. Land uses are identified based mainly on the information acquired when performing a cadastral land survey. However, land units are not surveyed every year, therefore the data on land uses could be un-updated in some situations. This information could not be accurately geographically represented, as it relates to land units that might have various land uses (e.g. a land unit is comprised of both a forest and an agricultural field). The land of various uses is measured by area and is not associated with geographical coordinates.

The CSB provides data on the use of agricultural land or the utilised agricultural area (UAA). The data are acquired from surveys on the use of agricultural land. The CSB data are not represented is a system of geographical coordinates and could not be shown geographically at the level of fields.

Information on agricultural land is also collected and aggregated by the RSS. This institution administers support payments in agriculture and aggregates information on the agricultural area declared for the payments. The area declared for support payments could be accurately identified geographically, as information on any field – coordinates of the field and crops grown in the field – is available. Figure 1 shows changes in the utilised agricultural area, according to the SLS, the CSB and the RSS.



Source: authors' calculations based on SLS, 2013, SLS, s.a., CSB, s.a., RSS, s.a.a (area reported before 2016, the area declared in 2016)

Fig. 1. **Utilised agricultural area in Latvia in the period 1990-2016, according to various information sources**

Over the past 20 years, according to the SLS, the agricultural area decreased from 2.5 mln. ha in 1996 to 2.336 mln. ha as of 1 January 2017.

According to the CSB, the UAA has both considerably increased and decreased in the period since 1990. A significant decrease in the UAA occurred in the period 1990-1999 when the UAA decreased from 2.53 mln. ha to approximately 1.6 mln. ha. After Latvia joined the EU, the UAA increased to 1.86 mln. ha in 2006. In the period 2006-2015, no change in the UAA was reported, yet in 2016 it increased again, reaching 1.93 mln. ha.

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According to the RSS, the area approved for the Single Area Payment Scheme (SAPS) has risen every year (except 2008) since 2004. The area approved for the SAPS in 2015 totalled 1.66 mln. ha. An area of the same size was declared for the SAPS in 2016 as well. Among the above-mentioned sources of information, only the RSS provides field coordinates. However, it is not enough to have the geographical coordinates of fields declared for the SAPS to comprehensively examine the organic soil area used in agriculture, as some area undeclared for the SAPS is also exploited in agricultural production. Furthermore, the organic soil area undeclared for the SAPS has to be also taken into account, as this area also produces GHG emissions.

For this reason, an examination of locations of all agricultural areas was performed. The identification of UAA geographical coordinates used the 2005 data of the RSS's Geographical Information System regarding the agricultural parcels that were classified by the RSS in 2005 as agricultural. The agricultural parcels were drawn from first-cycle blank-and-white orthophotographs (1994-1999) and second-cycle colour orthophotographs (2003-2005). The area of agricultural parcels identified in this way in 2005 totalled 2 343 587 ha and was comparable to the UAA reported by the SLS in 2015 – 2 352 615 ha (an average of the areas reported by the SLS on 1 January 2015 (2366118 ha) and 1 January 2016 (2352615 ha)), with a difference of only 9 028 ha or 0.38 %. This approach allows identifying the UAA spatially.

The RSS annually carries out a survey of agricultural parcels in accordance with Cabinet Regulation No. 635 "Procedures for Surveying and Identifying the Unfarmed Utilised Agricultural Area and Providing Information thereon" (2010), and the survey data allow dividing the identified UAA into categories – the area declared for the SAPS, the farmed area, the unfarmed area (overgrown with shrubs) or the overgrown area (with trees). The identification of the unutilised agricultural area is an important matter, as it was found that approximately 88 thou. ha were actually overgrown and more than 207 thou. ha were an unfarmed area (overgrown with shrubs). Besides, about 260 thou. ha were maintained in good agricultural condition but were not declared for the SAPS (authors' calculations based on RSS, s.a.b).

2. Identification of organic soils in Latvia

The identification of organic soils is important, as this information is used to compute GHG emissions in Latvia (National inventory…, 2017). These computations have to be performed using the IPCC guidelines (2013), including employing the IPCC definition of organic soils. To date in Latvia, information on soils has not been collected according to IPCC-defined soil texture classes, which are derived from a soil classification based on the World Reference Base for Soil Resources terminology, using a sequential approach based on necessary coarse criteria (Batjes, 2009). In Latvia, the largest information array on soils was formed during the Soviet period according to that period's soil classification (Tehniskie noradijumi..., 1987). That classification (improved and made more accurate) is still used today as well (Latvijas augsnu noteicejs, 2009). According to that classification, two soil classes – semi-hydromorphic and hydromorphic – and their several subtypes, fully or partially, could be considered to be consistent with the IPCC organic soil classes.

According to research studies by A.Karklins (2016b), the formation of hydromorphic soils was affected by aboveground or shallow underground waters over a long period, with the capillary layer reaching topsoil. Any kind of boggy soils with a peat layer of at least 30 cm thickness are called hydromorphic soils. Accordingly, any kind of hydromorphic soils in Latvia may be categorised as

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organic soils. Such soils could be present in fields, yet they usually form is small areas in valleys between hills, with no water outflow, and in ancient flood-lands.

Semi-hydromorphic soils or seasonally wet soils are present in areas with temporary and stagnant surface waters or medium deep groundwater, including in valleys and plains with poor water outflow, where soil density prevents the water from soaking into deeper soils layers. Only part of semi-hydromorphic soils in Latvia may be potentially categorised (besides, only in part) as organic (hereinafter in the text the ORG subtypes of semi-hydromorphic soils, which theoretically could be organic, from the soil list approved in 1987 are designated as ORG subtypes), and they are: mucky-humus sod-gley soils, mucky-humus sod-podzol-gley soils and alluvial bog soils. Table 1 shows the soil classification of Latvia and soil designations correspond to those of the 1987 soil classification (Tehniskie noradijumi ..., 1987). Table 1 also shows whether the 1987 soil classification corresponds with the newest list of soils present in Latvia (Latvijas augsnu noteicejs, 2009), identifying those soil subtypes in the new classification system that meet the IPCC organic soil criteria.

Table 1

Correspondence of 1987 soil classification items to the newest list of soils present in Latvia and the IPCC criteria

Class	Soil subtype names according to the 1987 soil list	Soil subtype names according to the 2008 soil list	IPCC organic soil
Hydro-morphic soils	Lowland bog peat soils (Tz)	Lowland bog mucky peat soil	Yes
		Lowland bog mucky-humus soil	Yes
	Lowland bog peat-gley soils (Tzg)	Lowland bog mucky peat-gley soil	Yes
		Lowland bog mucky-humus gley soil	Yes
	Transition bog peat soils (Tp)	Transition bog mucky-humus soil	Yes
		Typical transition bog peat soil	Yes
	Transition bog peat-gley soils (Tpg)	Transition bog mucky-humus gley soil	Yes
		Transition bog peat-gley soil	Yes
	Raised bog peat soils (Ta)	Typical raised bog peat soil	Yes
	Raised bog peat-gley soils (Tag)	Raised bog peat-gley soil	Yes
ORG subtypes of semi-hydro-morphic soils	Mucky-humus sod-gley soils (VGT)	Mucky-humus gley soil	No
		Peaty gley soil	Yes
	Mucky-humus sod-podzol-gley soils (PGT)	Mucky-humus podzol-gley soil	No
		Peaty podzol-gley soil	Yes
	Alluvial bog soils (AT)	Alluvial mucky gley soil	No
		Alluvial peaty soil	Yes

Source: authors' construction based on Karklins, 2016b; Latvijas augsnu noteicejs, 2009; Tehniskie noradijumi..., 1987.

The information available in Latvia on soil types does not allow identifying the organic soil area accurately. However, this information allows identifying the range of possible areas or a minimum and a maximum area between which the real organic soil area falls (Fig. 2), using the following equation:

$$OS_{area} = X + Y \quad (1);$$

Where:

OS_{area} is the organic soil area,

X is the hydromorphic soil area,

Y is the area with ORG subtype of semi-hydromorphic soils.

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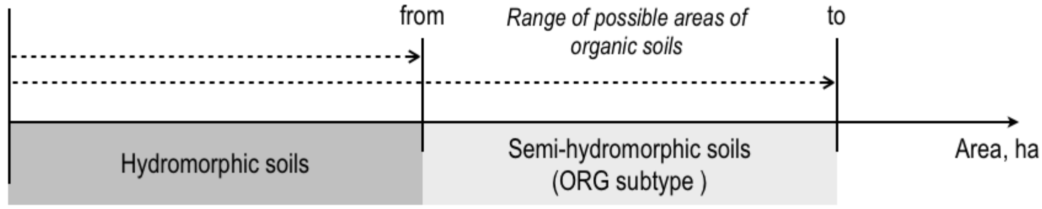
If the hydromorphic soil area is assumed to be X and the ORG subtype of semi-hydromorphic soils is soil area is assumed to be Y, the real organic soil area has to be in the range from X to X+Y.



Source: authors' construction

Fig. 2. **Range of possible organic soil areas**

Table 2 shows the characteristics of subtype soils that correspond to those of hydromorphic and ORG subtype of semi-hydromorphic soils, which could be useful for distinguishing the ORG subtype soils from other subtype soils. The most important characteristics were as follows: organic matter (OV) content, peat horizon thickness, soil acidity or alkalinity (pH) in the arable layer, depth of carbonates and glezation process.

Table 2

Soil subtype characteristics attributable to organic soils

Soil subtype names according to the 1987 soil list	Desig-nation	OV, %	Peat horizon thickness, cm	Arable layer pH	Carbo-nates, cm	Gleization
Lowland bog peat soils	Tz	≥ 50	≥ 50	≤ 5.5	n.d.**	Subsoil
Lowland bog peat-gley soils	Tzg	≥ 50	30-50	≤ 5.5	n.d.	Subsoil
Transition bog peat soils	Tp	≥ 50	≥ 50	≤ 5.5	n.d.	Subsoil
Transition bog peat-gley soils	Tpg	≥ 50	30-50	≤ 5.5	n.d.	Subsoil
Raised bog peat soils	Ta	≥ 50	≥ 50	≤ 5.5	n.d.	Subsoil
Raised bog peat-gley soils	Tag	≥ 50	30-50	≤ 5.5	n.d.	Subsoil
Mucky-humus sod-gley soils	VGT	20-50	≤ 30	≥ 6.5	≤ 60	Entire layer
Mucky-humus sod-podzol-gley soils	PGT	20-50	≤ 30	≤ 5.5	≥ 100	Entire layer
Alluvial bog soils	AT	≥ 50	≤ 30	≥ 6.0	n.d.	Entire layer

**In natural condition if not limed; **n.d. – the 1987 methodology does not specify this characteristic, yet it has to be taken into consideration if modernising the soil classification*
Source: authors' construction based on Karklins A., 2016b.

However, it has to be taken into consideration that the characteristics of soils (Table 2) were determined several decades ago and the soil subtypes distinguished in that period might not meet the modern criteria. As pointed out by Karklins (2016a), almost any soil rich in organic matter that was present in the utilised agricultural area was drained. A great deal of the soils were periodically tilled, limed and fertilised. All the mentioned factors contributed to the mineralisation of organic matter. Consequently, the content of organic carbon in soil and the layer of organic matter decreased. The last factor in particular could be a reason why former mucky-humus soils and peat soils that originally had a sufficiently thick layer of organic matter to be considered organic ones do not meet the criteria now. For this reason, explaining the area of organic soils based on aligning the national soil taxonomies gives only an approximate picture. A.Karklins also points out that the data have to be verified on the ground, especially in places the soil data for which were relatively older and where the agricultural area was intensively farmed, i.e. fields in particular.

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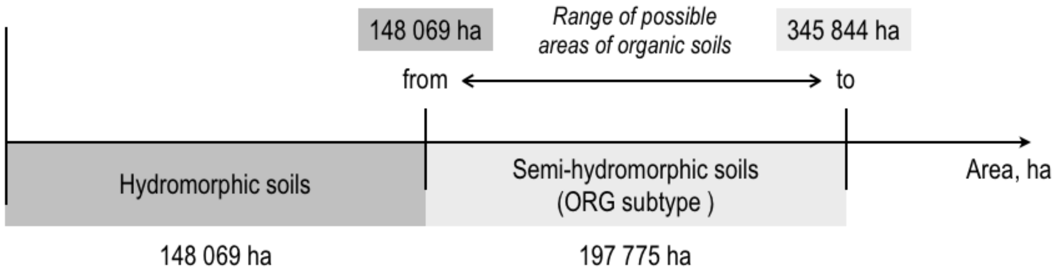

Source: authors' calculations

Fig. 3. **Estimate of the range of possible organic soil areas in Latvia**

An analysis of the soil map of Latvia and the RSS's Geographical Information System data (Latvia University…, 2017) reveals that the area of organic soils in Latvia, according to historical data, was in the range from 148 069 ha to 345 844 ha (Fig.3). This is 7-250 % more than presently assumed in the national inventory report of Latvia at 138 123 ha (National inventory.... 2017).

Conclusions, proposals, recommendations

1) Organic soils comprise an insignificant proportion of the total utilised agricultural area. A relatively high content of organic matter is characteristic of organic soils, and they are a very significant source of GHG emissions; for this reason, the organic soils have to be analysed in detail. In Latvia, there are favourable conditions for the formation of soils rich in organic matter.

2) The utilised agricultural area of Latvia, according to various information sources, is different. The SLS reported on an area of 2.336 mln. ha at the beginning of 2017, the CSB stated that the UAA was 1.93 mln. ha, while the area declared for the SAPS with the RSS totalled 1.66 mln. ha. The different areas make the identification of an organic soil area problematic in Latvia.

3) An examination of the national classification of organic soils as well as an analysis of the soil map of Latvia and the RSS's Geographical Information System data revealed that the organic soil area in Latvia, according to historical data, was in the range from 148 069 ha to 345 844 ha. It accounted for 6.3-14.8 % of the UAA reported by the SLS, 7.7-17.9 % of the UAA reported by the CSB and 8.9-20.8 % of the UAA declared for the SAPS; this area exceeded that specified in the national inventory report of Latvia by 7-250 %. For this reason, further research studies are necessary to accurately determine the organic soil area in Latvia.

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