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DEVELOPMENT OF SUSTAINABLE INTENSIFICATION EVALUATION METHODOLOGY FOR FARMLANDS IN LATVIA

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Abstract. Land resources are not fully exploited for agricultural production in Latvia. According to the Rural Support Service, in 2013 approximately 400 thousands ha of agricultural land were not declared for Single Area Payment Scheme. Increases in bioresources and food production in the world have become objective needs. Exploiting these land resources provides a possibility to increase agricultural output and economic efficiency in Latvia's rural areas. Yet, agricultural growth in Latvia's rural areas may not be in contradiction with sustainable development principles. It is necessary to intensify agricultural production by increasing agricultural output and contributing to comprehensively achieving sustainability indicators. To ensure sustainable intensification of Latvia's land resources, a theoretical model for calculating sustainable intensification indicators for agricultural holdings in Latvia, which involves social, economic, environmental and innovative sustainability, is being developed.

Key words: agriculture, sustainability, indicators, intensification.

JEL code: Q12, Q18 Q56

Introduction

According to Agricultural Census data, the utilized agricultural area (UAA) occupied 40% of the EU-28 territory in 2013. In the EU, 12.2 million agricultural holdings farmed 174.1 million UAA ha. The average size of agricultural holdings was 14.2 UAA ha. The greatest UAA per agricultural holding was reported in the Czech Republic (152.4 hectares) and in the United Kingdom (90.4 hectares). In Romania, 2/3 of the total agricultural holdings had less than 2 UAA ha (Eurostat, 2013).

UAA is an essential resource in any country's national economy. Its use requires an appropriate climate, rich soils and an advantageous geographic location. Research on the use of land resources conducted by scientists plays the leading role in meeting the increasing demand for food in the world, while at the same time avoiding global climate change. The basic idea of **sustainable intensification** (SI) of agricultural production is to increase the productivity of land resources, while at the same time enhancing environmental management.

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This means that the combination of factors of production used in agricultural production will not be the same for all management systems and industries.

The origin of the term sustainable intensification dates back to 1990 when development professionals sought ways how to tackle the increasing deficit of food in developing countries (Pretty J., 1997), (Beddingtonetal J.R., 2012), (De Schutter O., 2010) and (The Future of Food..., 2011). The sustainability of agricultural production, under the conditions of intensification, has to be measured. According to some authors, the most important dimension of agricultural production is the social sustainability of agricultural holdings (David S., 1989 and Webster P., 1999). Social sustainability indicators are subjective in nature and differ among farmers and other social groups in the way they are perceived (Van Calker et al., 2007). From the perspective of farmers, the economic sustainability of agricultural holdings is the most important. In scientific research, most often, the improvement of economic indicators of agricultural production is associated with more intensive and sustainable uses of land resources (Van Cauwenbergh N., et al., 2007). Scientific researches by some authors compare the model of organic and conventional agricultural holdings in the context of sustainability (Rasul G., Thapa G.B., 2003 and Proc R., Soc B., 2014). Yet, the newest scientific researches involve in-depth examinations of all the dimensions of sustainability in order to find the solutions to the use of land resources that balance the provision of socio-economic and eco-system services (Pretty J., 2011, Foley J., 2011 and Geraldo M.B., 2012). An opinion is supported that agricultural productivity has to be increased by employing innovative solutions on the present land area without changing rural landscapes (FAO, 2010 and Jaggard K.W., 2010). Such a development scenario may be provided by simultaneously controlling all the indicators of sustainability dimensions to achieve the targets set.

An understanding of term sustainability improved since 1987 when the UN World Commission on Environment and Development (the Brundtland Commission) produced a report Our Common Future. Systems for tracing sustainable development have been designed by creating indicators of progress. Some sustainable development indicators employed are as follows: Indicators of Sustainable Development (UN, 2007); Eurostat Sustainable Development Indicators (Eurostat, 2014); OECD Environmental Indicators (OECD, 2001); Environmental Performance Index (EPI) (Environmental..., 2014); Ecological Footprint (Working Guidebook..., 2014).

Under agricultural intensification, it is important to identify sustainability at the level of farms. Farms producing agricultural products are very diverse in terms of economic size and specialisation. Based on SI indicators, it is possible to compare these different farms in terms of social, economic, environmental as well as innovation sustainability.

Latvia's Rural Development Plan 2014-2020 has set a target to exploit up to 2.1 million UAA ha for agricultural production (Rural Development..., 2014). The total land area under crops will increase by 11% in Latvia. Researches on efficient uses of land resources in Latvia have been done (LLU, 2014), (Pilvere I., 2013) and (Lenerts A., 2013a), yet, opportunities for the SI of UAA at the level of farms have not been scientifically assessed and compared.

In the present research, the author sets an aim to develop a theoretical model for calculating sustainable intensification indicators (SIIs) for agricultural holdings in Latvia. The research object is the sustainable intensification of UAA and the research subject is a theoretical model for calculating SIIs of UAA. To achieve the aim, the following tasks were set: 1) to analyse the development of use of land resources in Latvia; 2) to define the indicators of SI of UAA; 3) to develop a theoretical model for calculating SIIs.

To execute the research tasks, analysis, synthesis, the logical and constructive methods, induction and deduction were employed. The study design process used special and general literatures, methodological materials on land use etc.

The research results are useful for national institutions, for example, the Ministry of Agriculture and the Ministry of Environmental Protection and Regional Development in order to provide a long-term and sustainable land use in Latvia.

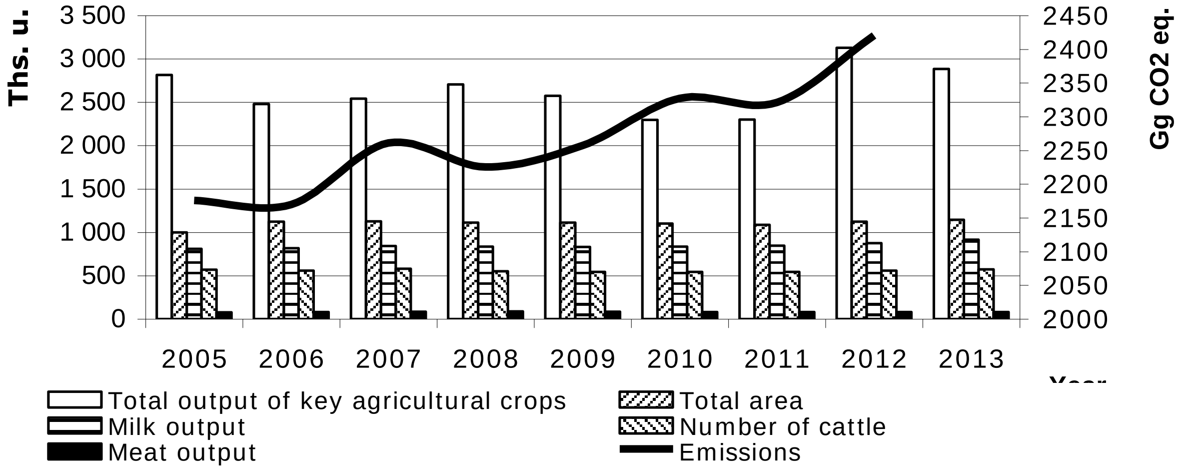
Research results and discussion

For a situation analysis and a selection of indicators, data of the Farm Accountancy Data Network (FADN) and the information of Latvia's Central Statistical Bureau (CSB) and National Inventory Report (NIR, 2014) were employed. Researches by scientists of Latvia University of Agriculture were used for identifying the potential of UAA.

1. Development of use of land resources in Latvia

Since the accession to the EU in 2004, agricultural production has grown in Latvia. With a growth rate of 5.6%, agriculture is the second fastest growing sector in Latvia (Agriculture in Latvia, 2014). Bioresources of agricultural origin are also used for biofuel (Lenerts A., 2013a) and biogas production (Lenerts A., 2012). Increases in output and economic activity in Latvia have to be ensured without increasing greenhouse gas (GHG) emissions from agriculture (European Parliament…, 2009).

Agriculture faced a decrease in output in the 1990's. Until 2000, the GHG emissions from agriculture declined 67%.



Source: author's construction based on the CSB, NIR, 2014

Fig.1. Changes in the main GHG emissions caused by agriculture

Yet, since 2000, with agricultural production growing, a gradual and stable increase in GHG emissions has been observed in Latvia (Fig.1, +15% from 2005 to 2013). Latvia's agricultural sector contributes to about 22% of the country's total GHG emissions (NIR, 2014).

Compared with the average EU indicators, agricultural production is still extensive and inefficient in Latvia. It is indicated by agricultural value added and GHG emissions. In the period 2005-2012, the use of fertilisers increased 52%, reaching 65.2 thousands a year, while an increase in productivity varied within a range of 20-30% (Agriculture in Latvia, 2014).

The conception of SI of agricultural production became topical in the beginning of the 21st century, responding to food security challenges in the world. Two clear trends emerged in rural areas: 1) a decrease in the agricultural area; 2) a decrease in the available agricultural area per capita (Koning N., 2009) and (Cassman K.G., 2010). In the period 2005-2012, according to the FAO Statistics Division, the agricultural area decreased by 5470 ths ha in the world, accounting for 0.2% of the total land area.

In Latvia, free agricultural land resources may be engaged in agricultural production by accepting the SI model. It will contribute to an increase in agricultural output, reducing effects on the environment. An indirect stimulus for assessing the sustainability of Latvia's agricultural production is the initiated negotiations on joining the Organisation for Economic Co-operation and Development. Achieving the sustainability indicators of agricultural production is an essential criterion for joining this organisation.

2. Indicators of SI of UAA

Agricultural sustainability is regarded as the key precondition for long-term agricultural production profitability in rural areas. To fully assess and comprehend the sustainability of a rural enterprise, indicators that are widely used and contain information on environmental quality, economic viability, employment, social environment and innovation have to be selected. The indicators may be used individually or as a component of a complex index. The primary aim of the present research is to select SI indicators that make significant effects on the social, economic, environmental and innovative sustainability of Latvia's farms. These indicators may be acquired from FADN, RSS and CSB databases compiling information on the performance of rural enterprises. The calculation methodology is explained in the next chapter of the paper.

The most characteristic indicator of SI is chosen for each dimension of sustainability based on a methodology developed by S.Bell and S.Morsi in their work „Sustainability Indicators: Measuring the Immeasurable?" (Bell S. and Morse S., 1999). Indicators are used in the EU to achieve the targets set, as ..."*indicators provide the basis for assessing progress towards the long-term objective of sustainable development. Long-term targets only have meanings as policy goals if progress towards them can be assessed objectively*" (European Commission, 2001). So, sustainability indicators are needed to assess the implementation of sustainability measures under the EU CAP.

Economic Indicators. The economic sustainability of farms in Latvia is strongly associated with economic processes in global markets. Product prices and demand make significant effects on these indicators. Five indicators, which indicate the productivity, profitability and viability of farms, were selected in the present research. Ensuring the economic sustainability of farms is not always possible by meeting environmental and sustainability requirements. The source of indicator data is the FADN, and the data are summarised in Table 1.

Table 1

Economic sustainability indicators of agricultural holdings

Indicator	**Measure**	**Unit**
Productivity of labour	Income per unpaid labour unit	EUR/labour unit
Productivity of land	Gross output per hectare	EUR/hectare
Profitability	Market based gross margin per hectare	EUR/hectare
Viability of investment	Farm is economically viable	1=viable, 0= not viable
Market orientation	Output derived from the market	%

Source: author's construction

Environmental indicators. Scientific experience about the effects of farms on the environment has become more profound. The leading EU Member States in agricultural production have introduced a precise data collection system to determine the effects on the environment. Latvia will have to introduce a similar data collection system for the purpose of calculating environmental SIIs. The indicators of environmental sustainability are selected taking into account the following: air quality/climate change; risk to water quality; habitat and biodiversity.

Table 2

Environmental sustainability indicators of agricultural holdings

Indicator	Measure	Unit
GHG emissions per farm	IPCC estimate/ farm	Tonnes CO2 equivalent/farm
GHG emissions per kg of output	IPCC estimate/ kg of output	Kg CO2 equivalent/kg output
Nitrogen (N) balance	Risk to water quality	Kg N surplus/hectare
Nitrogen (N) use efficiency	Nitrogen use efficiency /product	Kg N surplus/unit product
Emissions from fuel and electricity	CO2 equivalent/kg output	Kg CO2 equivalent/kg

Source: author's construction

GHG emissions are the primary cause of global warming. One of the most pressing challenges for Latvian agriculture will be to produce more food while reducing the GHG emissions. Agriculture was Latvia's second largest emission source by sector, accounting for 22% of the total GHG emissions in 2013 (NIR, 2014). Two greenhouse gas emission indicators are developed. Both indicators are calculated using IPCC coefficients and conventions. One is expressed on a per farm basis while the other is expressed per unit of product.

Social indicators. Agriculture provides the viability of rural environment and develops territorial infrastructures. It is usually the only economic activity in rural areas.

Table 3

Social sustainability indicators of agricultural holdings

Indicator	Measure	Unit
Household vulnerability	Farm business is not viable - no off-farm employment	Binary, 1= Yes, 0= No
Education level	Educational attainment	Count variable 1 - 51
Isolation risk	Farmer lives alone	Binary, 1= Yes, 0= No
High age profile	Farmer is over 60 years of age and no household member is less than 45	Binary, 1= Yes, 0= No
Work life balance	Work load of farmer	Hours worked on the farm

Source: author's construction

When defining social SIIs, life quality indicators have to be considered depending on the kind of chosen occupation. Farm revenues are not regarded as an indicator of social sustainability because it is more important to assess the overall wellbeing and life quality of rural communities in accordance with sustainability principles.

Innovation Indicators. The market of agricultural goods and the market of resources used in production are constantly changeable. Innovation enables farms to remain competitive by introducing innovations and producing more products with fewer resources. Innovation is a broad term, as it means "new to the firm, new to the market or new to the world" (OECD and Eurostat, 2005). Innovation is regarded as: a new process; a new product; new forms of management; and new supply sources used.

Table 4

Innovation sustainability indicators of agricultural holdings

Dairy	Cattle	Sheep	Tillage
Milk recording	Quality assurance member	Quality assurance member	Forward selling
Discussion group member	Reseeding	Reseeding	ICT usage
Spring slurry spreading	Soil testing	Soil testing	Soil testing

Source: author's construction

At the level of farms, there are a lot of innovations referring to the process of innovation: new production techniques; higher resource use efficiency; new cooperation models etc. More efficient uses of resources (land, livestock, fertilisers, labour and technologies) will lead to reductions in production costs. Accordingly, the introduction of new technologies and participation in advanced training courses are used as innovation sustainability indicators.

Regularly collecting such data allows assessing the efficiency of innovations and technologies in the future. Employing SIIs enables assessing innovations at the level of farms, thus identifying their economic efficiency and environmental protection effectiveness in achieving the overall sustainability of farms.

3. Theoretical model for calculating sustainable intensification indicators

The present research aims to assess the sustainability of a particular industry numerically. The most precise way of assessing it involves calculating a synthetic SII for various factor groups. It is important that it is possible to identify changes in a process in time, and it is desirable to shape a notion of the period when negative effects have been minimal. At the same time, the indicators have to be instruments assisting in simplifying the obtaining and analyses of information and in identifying problems well as in formulating and making a government policy aimed at solving the problems.

Pair-wise analysis was employed to identify the significance of effects of the factors affecting the sustainability of an industry. An analysis involved a matrix in which the factors affecting the sustainability of an industry were put horizontally and vertically. The number of a factor that is superior over another is written in an appropriate cell in the horizontal row. The final cell of the row shows the number of advantages of the given factor. The total number of advantages for all the factors is calculated summing up the values in the vertical column. This sum is assumed to be equal to 1. The proportion of each factor's number of advantages indicates the given factor's relative weight of effects in a range from 0 to 1. So, each factor's significance of effects is assessed. The SI model takes into consideration a factor's numerical value by multiplying it by the coefficient of significance.

Further, the indicators are normalised, the key purpose of which is to avoid a situation when one or several factors may prevail, as the range of factor values may be very diverse. The normalised indicators are derived from the initial indicators that are expressed in different units of measurement. In the result of normalisation, the initial units of measurement disappear and, consequently, different indicators become comparable. After analysing the most popular data normalisation methods, the author has chosen min-max normalisation [from 0 to 1] in calculating the SIIs, which is performed if values are only positive and, in the result of normalisation, they will be within a range from 0 to 1. The normalisation is performed according to Formula 1:

$$a_i^{'} = \frac{a_i - a_{\min}}{a_{\max} - a_{\min}}, (1)$$

where: $a_i^{'}$ - normalised value of a factor;

a_i - actual value of a factor;

$a_{\min}$ and $a_{\max}$ - minimum and maximum values of a factor.

The next stage involves the composition of a SII function. The sustainability model developed by the author for Agricultural Industries III involves four groups of factors affecting sustainability and is expressed with Formula 2:

$$IINI = (\alpha_1 F_E + \alpha_2 F_S + \alpha_3 F_V + \alpha_4 `F_{IN}) \rightarrow 1, (2)$$

where: SII – sustainable intensification index of an industry;

$\alpha_1 ... \alpha_7$ - relative weights of factors;

F_E - economic sustainability index;

F_S - social sustainability index;

F_V - environmental sustainability index;

F_{IN} - innovation sustainability index.

In Formula 2, the agricultural industry's SI tends towards 1, as a min-max normalisation was performed, which means that a maximum value the SII can reach is 1. Each factor group indicator F_n is computed taking into account the indicators of the given factor groups, applying the above mentioned min-max normalisation. To hold the index value within a range from 0 to 1, an arithmetic mean of the indicators of certain factor groups is computed (Formula 3).

$$F_n = \frac{1}{N}\left(\frac{f_1 - f_{\min_1}}{f_{\max_1} - f_{\min_1}} + \frac{f_2 - f_{\min_2}}{f_{\max_2} - f_{\min_2}} + ... + \frac{f_n - f_{\min_n}}{f_{\max_n} - f_{\min_n}} \right), (3)$$

where: F_n - index of the group of factors affecting the agricultural industry's SI;

$f_1 ... f_n$ - actual values of factor indicators;

f_{min}, f_{max} - minimum and maximum values of factor indicators;

N – number of factor indicators.

Conclusions

1. The UAA in the EU and Latvia is a significant resource and occupies 40% of the total territory.
2. In Latvia, 1815.9 thousands ha of agricultural land is exploited in agricultural production, and 400 thousands UAA ha are additionally available.
3. The agricultural sector contributes to 22% of Latvia's total GHG emissions, with an increase of 15% from the base year, which will surge owing to an increase in the UAA.
4. Employing adequate indicators of agricultural holdings, it is possible to compute SIIs in order to identify sustainability in agricultural production in Latvia.

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