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Framework for assessing the farm relative sustainability: a Lithuanian case study

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Abstract: The aim of the study was to develop an analytical tool to assess the relative sustainability of family farms using the FADN data. This tool was based on the set of 23 indicators that covered three main components of sustainability (economic, environmental and social). The min-max approach was employed to normalise the selected indicators expressed in variety dimensions for their need to be put on a common basis. The factor analysis was used to estimate weights for the selected indicators to construct sub-indices and then the sub-indices were aggregated into the farm relative sustainability index (FRSI). The FRSI and sub-indices ranged from 0 to 1 (scaled into three intervals), assuming that the closer to 1 were the values of the index and the sub-indices the higher was the relative sustainability of the farm. The analytical tool has been applied to the Lithuanian FADN database for 2003 and 2012. The research revealed that the FRSI in 2003 and 2012 fell within the medium sustainability interval in all analysed farm size classes. The best sustainability situation in the year 2003 was determined on the large-sized farms, while the best sustainability situation in the year 2012 was established on the mid-sized farms.

Keywords: farm relative sustainability, family farm, sustainability indicators, FADN data

Agriculture plays an important role in the economies of many countries in terms of its potential to influence a wide range of issues that are related to sustainable development, including economy, employment, food security, trade flows, poverty, human health, climate change, use of natural resources and biodiversity. Currently, the situation in agriculture has been characterized by the declining rates in the productivity growth, the decrease in the share of global agricultural exports from the developing countries, the increase in the use of agrochemicals, resulting in the negative impact on human health, ecosystems and biodiversity, increasing levels of the greenhouse gas emissions and the inequitable distribution of benefits among countries and different segments of societies within countries (UNEP 2012). The FAO (1989: 65) defined the sustainable development of agriculture as "the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable".

The focus of international organisations on agricultural sustainability has prompted the emergence of studies in this field and, as noted by Schader et al. (2014: 1), "sustainable development has become one of the most frequently used frameworks for analysing agricultural and food sectors in a comprehensive and holistic way". However, as argued by Astier et al. (2012), most agricultural sustainability analyses are only applied at the regional, national, or global level. Moreover, the indicators used in these analyses are not sufficiently adapted to initiate changes at the farm level that would lead to the mitigation of the negative impact on natural resources and environment. It should be noted that the indicator sets for the farm sustainability assessment differ by their scope and purpose. As stated by Marchand et al. (2014), no sustainability assessment tool is "one size fits all". As suggested by Binder et al. (2010) and Marie (2011), the sustainability assessment of agricultural systems was still in the development stage and had shortcomings. The most commonly-used data source for the evaluation of the farms economic, social and environment sustainability is the farmers' survey,

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employing a structured questionnaire or/and an in-depth interview (Sauvenier et al. 2005; Urutyan and Thalman 2011; Jalilian 2012). Therefore, recently the available databases as information sources such as the EU Farm Accountancy Data Network (FADN) have been employed (Longhitano et al. 2012; Van der Meulen et al. 2013; Barnes and Thomson 2014; Ryan et al. 2014; et al.). In the previous farms sustainability studies using the FADN data, Westbury et al. (2011) and Gerrard et al. (2012) emphasized more the importance of the FADN on the formation of the environmental indicators, whereas Ryan et al. (2014) narrowed the environmental sustainability approach and Van Passel and Meul (2012) did not develop social indicators. Moreover, in some researches concentrating particularly on a certain faming type (Van der Meulen et al. 2013), on the sustainability intensification concept (Barnes and Thompson, 2014) and on the regional context of farming (Longhitano et al. 2012), the specific sets of indicators for the farm sustainability assessment were developed. On other hand, as the FADN originally was developed for measuring the farm's income and economic performance, the developed indicators should be verified in the new context (Gerrard et al. 2012).

Farm sustainability assessments were conducted in some countries, such as the Belgium (Sauvenier et al. 2005), Spain (Gomez-Limon and Sanchez-Fernandez 2010), Iran (Jalilian 2012), the Netherlands (Van der Meulen et al. 2013), Armenia (Urutyan and Thalman 2011), Greece (Dantsis et al. 2010), the Veneto region in Italy (Longhitano et al. 2012), Scotland (Barnes and Thompson 2014) and Ireland (Ryan et al. 2014). In Lithuania, the farm sustainability has so far been analysed from the perspective of organic farming only (Čiegis 2009; Skulskis 2010). Our research interests focus on the assessment of the farm sustainability in Lithuania. The study outlines the development of an analytical tool to assess relative sustainability of family farms using the FADN data.

MATERIAL AND METHODS

Marchand et al. (2014) suggested two working definitions of the sustainability assessment tools at the farm level, i.e. the full sustainability assessment (FSA) and the rapid sustainability assessment (RSA). The FSA tools use detailed farm data and/or expert information, require trained advisers and/or expert visits to gather data, and are rather long and expensive in duration. The RSA tools use the farmer's knowledge or the readily available data, allow auditing by the farmers or advisers, and are relatively short in duration. The RSA tools are more directed toward learning and can act as a trigger for the farmers to become interested in farm sustainability. Furthermore, such an assessment can raise the farmers' awareness and reveal particular problems or barriers in the development of farm sustainability. When farmers get interested in sustainability, or its specific aspects, they can concentrate on monitoring these particular aspects by using the FSA tools. The authors stress the farmer's knowledge and the readily available data as sources of information for the RSA tool. Our study focuses on the FADN data. In Lithuania, the farm sustainability has not been investigated yet. Therefore, the arm sustainability concept is new and raises a number of issues to be discussed between decision makers such as farmers, policy makers and other stakeholders.

To develop a farm-level relative sustainability index (FRSI), the OECD (2008) guidelines were followed. Based on the indicator selection principles like those of Bellagio (Hardi and Zdan, 1997), SMART (Lockie et al. 2005) and the desired characteristics for sustainability indicators provided by Guy and Kibert (1998) FRSI was constructed. The sequence of development of the indicators sets for the FRSI is provided in Figure 1.

The first stage was meant to identify the potential indicators and the formation of their initial sets by three sustainability dimensions based on the sets of indicators and the rationale behind their selection in the earlier studies on farm sustainability (Sauvenier et al. 2005; Gomez-Limon and Sanchez-Fernandez 2010; Dantsis et al. 2010; et al.). The second stage focused on the farm sustainability indicators developed using the FADN data (Longhitano et al. 2012; Van der Meulen 2013; Barnes and Thomson 2014; et al.). The indicators that can be replicated to identify the same variables were excluded at the third stage. At the fourth stage, the additional data necessary to calculate the proxy indicators were identified. The fifth stage involved a detailed analysis of data in the farm accounting statements. The extension of the indicator sets and the elimination of the farm type-specific indicators were performed at the sixth stage. To avoid double counting at the aggregation stage analysis of the correlation between the indicators was carried out employing the Pearson's test at the seventh stage. At the eighth stage, examining

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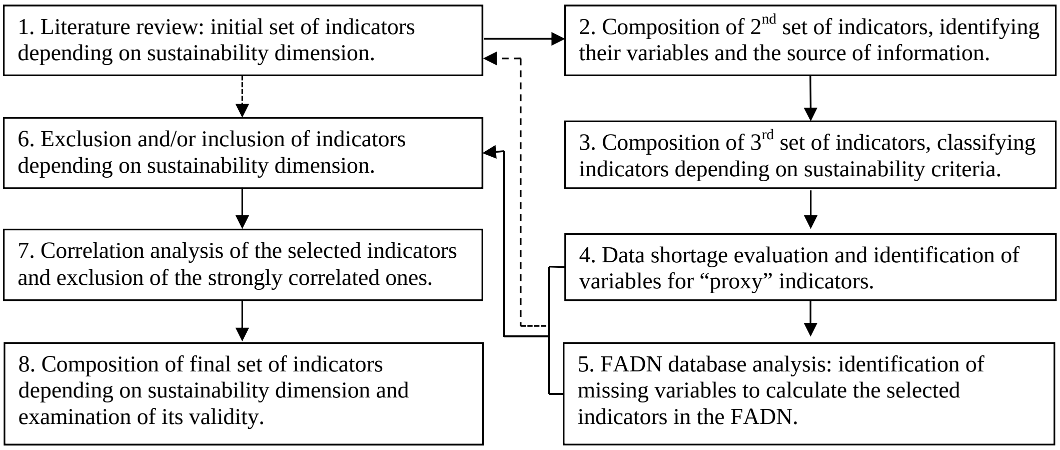

Figure 1. Succession of composition of indicators for farm sustainability assessment using the FADN data

the prepared set of indicators for the farm relative sustainability assessment by validating the coverage of the subthemes as a reference the Sustainability Assessment in Food and Agriculture Systems (SAFA) Guidelines (FAO 2013) were employed. Therefore, the SAFA is a globally applicable guiding framework for the sustainability assessments in the food and agricultural sector. Moreover, Schader et al. (2014) proposed to apply the SAFA to assess the analytical tools that are developed for the farm sustainability assessment.

The final set of indicators for the relative sustainability of the farms assessment included quantitative and qualitative indicators. The application of qualitative method provides a better understanding of the system performance as suggested by Diakaki et al. (2006). The present study was initiated to develop qualitative indicators to evaluate environmentally friendly farming (environmental dimension), the pluriactivity of the farmer himself/herself and other family members, the workload exceeded, the farming continuity and the farmer's age (social dimension).

Economic dimension. The developed indicators for evaluation of the economic sustainability of farms are presented in Table 1. No strong correlations were found between the developed economic indicators what could have confirmed that these indicators could have been adapted to the farm sustainability analysis. Based on the reviewed literature and data derived from the FADN (Longhitano et al. 2012; Van der Meulen et al. 2013; et al.), the most commonly used economic indicators refer to the farm's productivity and profitability. At present, the studies developed using farmers' survey employ variables such as the farm economic stability, economic viability, independence, transferability, etc.

Environmental dimension. Seven farm level environmental indicators of sustainability are considered (Table 2). A wide variety of environmental variables were developed using the farmers' survey data such as the physical and chemical soil properties, the water quality and energy produced and consumed on the farm and other variables are presented. When FADN data is employed the analysis is limited by the data

Table 1. Economic indicators of the farm

Notation	Variable: indicator
e_1	Labour productivity: farm gross value added per 1 annual work unit (EUR/AWU)
e_2	Capital productivity: ratio of farm gross value added (at basic price) to capital
e_3	Land productivity: farm gross value added (at basic price) per 1 hectare of UAA (EUR/ha)
e_4	Solvency: ratio of farm total assets to total liabilities
e_5	Farm income: family farm income per 1 family work unit (EUR/FWU)
e_6	Fixed capital formation: investment in long-term assets per 1 hectare of UAA (EUR/ha)
e_7	Farm diversification: ratio of revenue from other gainful activities to total farm revenue (per cent)
e_8	Farm risk management: ratio of agricultural insurance premiums (for animals, crops, technique and farm buildings) to variable costs (per cent)

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Table 2. Farm environmental indicators

Notation	Variable: indicator
n_1	Use of chemical fertilizers: amount of chemical fertilizers per hectares of UAA (kg/ha UAA)
n_2	Use of pesticides: costs of pesticide per hectares of UAA (EUR/ha)
n_3	GHG emission: GHG emission per 1farm (t CO_2-eq.)
n_4	Energy intensity: ratio of cost of electricity, equipment, heating, transport fuel and oil to farm gross value added
n_5	Biodiversity on a farm: Simpson diversity index
n_6	Meadows and pastures: share of meadows and pastures (per cent of UAA)
n_7	Livestock density: livestock units per 1 hectare of UAA (LSUs/ha)
n_8	Environment-friendly farming: organic farming, participation in agri-environmental and food quality schemes (score)

availability. Therefore, it was common to use the variables like the fertilizer and pesticide use on farms, the landscape and biodiversity conservation, and the farming practice for assessment of environmental sustainability. To resolve the lack of data issue, the proxy indicators were developed in this study. The *use of chemical fertilizers* was derived by approximation, i.e. following Westbury et al. (2011), the amounts of fertilizer used in a farm have been derived from the information on the total expenditure on fertilizer and dividing this by a standard fertilizer cost to estimate the overall quantity used. Westbury el al. (2011) the method based on the approximation was used to derive the application of fertilizes. It should be noted that under the framework of the European Council Regulation (EU) No. 1320/2013, the collection of information on the quantities of chemical fertilizers N, P_2O_5, K_2O applied on farms was launched on 1 January 2014 in Lithuania. This means a higher accuracy of the data for a further research. The greenhouse gas (GHG) emissions at the farm level were computed applying the methodology presented by Coderoni et al. (2012). The GHG emissions from chemical fertilizers were estimated, as the fertilizer quantities have not been reported in the Lithuanian FADN so far.

The correlation analysis of environmental indicators suggested a strong relationship between the fertilizer and pesticide use on farms. Nonetheless, both indicators were computed in the farm sustainability studies, as they represent different sources of pollution. The indicator of the pesticide use has been rated as the most significant and the indicator of the fertilizer use – the second by significance among the indicators of other environmental issues in the farm sustainability assessment by Dantsis et al. (2010). Therefore, they were included into the final set of indicators for the sustainability assessment of family farms within the framework of this study.

Social dimension. A number of diverse social variables such as labour conditions, the farmers' involvement into community activities, public decision making and trainings, the farmers' health, the quality of farm products, human-nature relationships and others were included into the farm sustainability studies based on the farmers' survey (Sauvenier et al. 2005; Van Passel and Meul 2008; Urutyan and Thalman 2011).Whereas, the family labour, labour supply, the demographic viability (farmer's age), the off-farm income are ones of the most commonly used variables to assess the farm sustainability in other recent

Table 3. Farm social indicators

Notation	Variable: indicator
s_1	Family work: ratio of hours worked by family members to total hours worked on farm (per cent)
s_2	Jobs on farm: total annual hours worked converted into full-time equivalents (FTE)
s_3	Wage ratio on farm: ratio of average annual wages paid for hired workers on farm to average gross annual earnings in whole economy (per cent)
s_4	Pluriactivity: income from off-farm activities (score)
s_5	Workload exceeded: annual hours worked on farm by each family member exceed 1.5 AWU (score)
s_6	Continuity of farming: risk of abandonment of agricultural activity (score).
s_7	Farmer's age: under 35 years old, between 35 and 65 years old and 65 years and older (score)

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studies developed using the FADN data (Longhitano et al. 2012; Barnes and Thomson 2014, Ryan et al. 2014). Seven social indicators of sustainability of family farms were developed in this study (Table 3). A strong adverse relationship was observed between the family work and the wage ratio (r = −0.815). As the former indicator refers to internal dimension of the farm and the latter indicators concerns the external dimension related to the community's demands, both indicators were included in the final set of social indicators.

Finally, the examination of the final set of indicators by their coverage of sub-themes of the SAFA guidelines was developed. This set includes eight economic indicators that cover the SAFA economic sub-themes (such as the long-ranging investment, profitability, stability of market, employment, risk management, and value creation), eight environmental indicators that cover the SAFA environmental sub-themes (such as the GHG, the soil quality, ecosystem integrity, species diversity, energy use, animal health) and seven social indicators that cover the SAFA social sub-themes (such as the quality of life, working hours, the physical and psycho-social health) .

Prior to the composition of the Farm Relative Sustainability Index (FRSI), the weights for the indicators (Tables 1 to 3) were assigned. The factorial analysis was employed using the method proposed in the Handbook on Constructing Composite Indicators (OECD 2008), namely, grouping the individual indicators with the highest factors loadings into the intermediate composite indicators. Then the intermediate composites were aggregated by assigning a weight to each one of them equal to the proportion of the explained variance in the data set. The estimated weights of the farms sustainability indicators based on the factor analysis are given in Table 4.

Table 4. Weights estimated for the economic, environmental and social indicators based on the factor analysis

Indicators					
economic		environmental		social	
notation	weight	notation	weight	notation	weight
e_1	0.15	n_1	0.24	s_1	0.24
e_2	0.09	n_2	0.22	s_2	0.20
e_3	0.16	n_3	0.12	s_3	0.18
e_4	0.09	n_4	0.08	s_4	0.08
e_5	0.09	n_5	0.07	s_5	0.06
e_6	0.15	n_6	0.06	s_6	0.12
e_7	0.15	n_7	0.12	s_7	0.12
e_8	0.12	n_8	0.09	–	–
Total	1.00	Total	1.00	Total	1.00

The set of quantitative and qualitative indicators was developed for the assessment of farm sustainability. The min-max approach was employed to normalise the quantitative indicators expressed in a variety of dimensions (Tables 1 to 3) to the aim to put them on a common basis. Then quantitative indicators were scaled from zero to 1, where zero corresponds to the worst possible value of the indicator and 1 to the best.

The qualitative indicators were normalised by ranking, where the maximum value equalled to 1, the average value equalled to 0.5 and the minimum value equalled to 0. The value of the environmental indicator (environmentally friendly farming) and the values of social indicators (pluriactivity, workload exceeded, farmer's age) were scaled as follows: the maximum value equalled to 1, the average value equalled to 0.5 and the minimum value equalled to 0. The environment-friendly farming was ranked following 3 values scale, where the maximum value equalled to 1 when farming was organic; the average value equalled to 0.5, when the farming was in the transitional period and/or the agri-environmental and food quality schemes were implemented on the farm; and the minimum value equalled to 0, when farming was not organic and considered schemes were not implemented. Workload exceeded was ranked as follows: the maximum value was attributed to farms when no one of the farm member' workload exceeded 1.5 AWU, the average value was attributed to farms, when at least one farm family member's workload value exceeded 1.5 AWU and the minimum value indicated farms when at least two farms members' exceeded considered value. The continuity of farming ranks were built upon the farm net income per AWU and the farmer's age, where the maximum value was given to farms with the younger age profile of farmer (the farmer age under 65 years old) and the farm' income indicator was above an average, the minimum value was attributed to farms with a lower age profile (the farmer age was 65 years old or over) and the farm income was below an average, and the estimated average value to the farms which satisfied one of the considered criteria. The farmer age was ranked attributing the maximum value to farms when the farmer was under 35 years, the average value was given to farms when farmer was aged 35 to 65 years, and the minimum value was given to farms when the farmer was 65 years old or older. The pluriactivity

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assessment ranks were distributed as follows: the maximum value was attributed to farms which indicated the off-farm income and the minimum value was attributed to farms, which did not indicate any off-farm income.

Once the weights to the selected indicators were obtained, there was a possibility to aggregate them into sub-indices (economic, environmental and social) and into the sustainability index. As Krajnc and Glavič (2005) emphasised, the integrated information on sustainable development is essential for the decision-making. The authors proposed the calculation of the sustainability index as a step-by-step procedure of grouping various basic indicators into the sustainability sub-index for each set of sustainability indicators. Sub-indices can be expressed in the equation (1) proposed by Krajnc and Glavič (2005):

$$I_{sub,ji} = \sum_{i=1}^{n} W_{ji} \times I_{N,jit}$$

$$\text{with condition: } \sum_{ji}^{n} W_{ji} = 1 \qquad (1)$$

where $I_{sub,ji}$ denotes the sustainability of sub-index for a group of indicators j (economic j = 1, environmental j = 2, social j = 3) in time (year) t. W_{ji} denotes the weight of the indicator i for the group of sustainability indicators j. To combine sustainability sub-indices into the family farm sustainability index, the 2nd equation was employed (Krajnc and Glavič 2005):

$$I_{index,t} = \sum_{jt}^{n} W_j \times I_{sub,ji} \qquad (2)$$

where Wj = the factor representing the weight given to the sub-index.

In our study, assignments of the weights to the sub-indices were based on the triple bottom line approach of sustainability, so that the given weight was equal to all three dimensions of sustainability. The final equation of the FRSI was:

$$FRSI = 0.33 \times I_{sub,j1} + 0.33 \times I_{sub,j2} + 0.33 \times I_{sub,j3} \qquad (3)$$

where:
$I_{sub,j1}$ = the value of the economic sub-index,
$I_{sub,j2}$ = the value of the environmental sub-index
$I_{sub,j3}$ = the value of the social sub-index

The calculated values of the index and the sub-indices may vary within the interval from 0 to 1. According to the FAO (2013), this interval could be divided into five scales, whereas Longhitano et al. (2012) suggested dividing it into three scales.

In this study, the FRSI and sub-indices ranged from 0 to 1 (scaled into three intervals), assuming that the closer to 1 were the values of the index and sub-indices, the higher was the achieved level of the relative sustainability of the farm:

– low sustainability score which fell within the interval [0; 0.33], meaning that the farm was unsustainable or of a low sustainability;
– medium sustainability score which fell within the interval [0.34; 0.66] as considered to be the medium level of farm sustainability,
– high sustainability score which fell within the interval [0.67; 1], meaning that the farm was either fairly sustainable or sustainable.

The main set of empirical results presented in the study was based on a static analysis using the individual farm records of 450 farms sampled randomly for 2003 and 2012 from the Lithuanian FADN with

Table 5. Farms sample distribution according to farm size classes in 2003 and 2012 years

Farm size classes of UAA (ha)	2003		2012	
	number of farms	average farm size (ha UAA)	number of farms	average farm size (ha UAA)
Less than 10 ha	20	6,8	23	6.3
From 10 to 20 ha	38	15.7	33	14.4
From 20 to 30 ha	37	25.4	36	24.9
From 30 to 40 ha	46	34.8	32	34.8
From 40 to 50 ha	39	44.7	40	45.5
From 50 to100 ha	130	71.9	120	72.1
From 100 to150 ha	60	124.1	37	121.8
150 ha or over	80	295.2	129	308.0
Total	450	101.0	450	127.4

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95% of the confidence level. The descriptive statistics of the estimated indicators is presented in the Annex. According to the utilized agricultural area (UAA), the farm size was categorized into eight classes (Table 5).

The ANOVA test was used to measure the statistical significance of the difference in the indicator values between the farm size classes. A *p*-value of less than 0.05 ($p < 0.05$) was considered to indicate a statistically significant difference across the farm size classes. The Statistical Package for Social Science (SPSS 21) was employed for processing and analysis of the collected data.

RESEARCH RESULTS

The calculated average normalized values of farm sustainability indicators according to the farm size classes are presented in Tables 6–8. These data indicate the economic, agri-environmental and social state in the average terms by comparing with the best results achieved in Lithuanian farms in 2003 and 2012. Table 9 summarizes the results on the relative farm sustainability expressed in the economic, environmental and social sub-indices and in the FRSI in the considered years across the farm size classes. The most interesting issues in the context of farm sustainability are summarized below by each sustainability dimension and the farm size class.

The average normalized values of the productivity indicators are presented in Table 6 (for more details, see indicators e_1 to e_3, Table 1). The labour productivity differs considerably across the farm size classes, particularly between the small-sized and large-size farms. The highest level of labour productivity was achieved in the farm size class of 150 ha UAA or over in both considered years. Whereas, the capital productivity differs slightly between the farm size classes. The highest capital productivity was achieved on the largest farm size classes in both research years and the lowest in the mid-sized farms (from 20 to 30 ha UAA and from 20 to 50 ha UAA in 2003 and 2012, respectively). By contrast, the highest level of land productivity was found in the small-sized farms.

The average normalized values of family farm income and financial indicators (for more details, see indicators e_4 to e_6, Table 1) by the farm size classes has shown that the large farms were the most solvent in 2003 and 2012. It should be noted that the solvency gap across the farm size classes was six-fold in the year 2012. In the considered years, the highest family farm income per 1 FAWU was generated in farms of 150 ha UAA or over. Moreover, this income gap across farm size classes was fivefold in 2012. The findings for the fixed capital formation showed that the best results of investment were achieved in the largest farm size class (150 ha UAA or over) in 2003, whereas, in 2012, the investment was achieved at two considered farm size classes, i.e. from 30 to 40 ha UAA and from 100 to 150 ha UAA (Table 6).

Two indicators referring to the farm risk management have been included into the farm sustainability assessment, as presented in Table 1 (see indicators e_7 and e_8). The analysis of the average normalized values of these indicators suggested that farms in all size classes make little use of the internal farm capacity to reduce the agricultural business risk, for example, the development of other gainful activities like agri-tourism, agricultural services (Table 6). This is evidenced by very low normalized values of the indicator e_7 in both considered years. A higher normalized value of this indicator was found in farms in the size class from 10 to 20 ha UAA in 2003 and in farms in the size class from 30 to 40 ha UAA and less than 10 ha UAA in 2012. On the other hand, higher normalized values of the indicator e_8 showed that farms tend to make a better use of external tools than of the internal ones to reduce the agricultural risk. Normalized values of the ratio of the agricultural insurance premiums to variable costs have showed that more efforts were made by the small-sized farms (less than 20 ha UAA) in 2003 and by the small and medium-sized farms (less than10 UAA ha and from 40 to 50 ha UAA, respectively) in 2012.

The average normalized values of the environmental indicators presented in Table 7 show the differences of the nature conservation and agri-environmental protection performance across the observed family farms size classes. The negative variables in the environmental terms (for more details, see indicators n_1-n_4 and a_7, Table 2) suggested that the use of chemical fertilizers (indicator n_1) was the most environmentally favourable on farms from 20 to 50 ha UAA in both considered years. The lowest intensity of the pesticide use (indicator n_2) found in the farms in the medium-size class (from 30 to 40 and from 30 to 50 ha UAA in 2003 and 2012, respectively). It should be noted that the low variation of the normalized average values of the chemical fertilizers and pesticides usage across the farm size classes was determined in the year 2003 (7.6% and 7.3%, respectively), while the variation in the year 2012 was moderate (15.2%

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and 15.4 %, respectively). This indicates that the difference in the intensity of the use of these chemical substances across the considered farms size classes increased within the decade.

The average normalized values of the GHG (CH_4) emissions from the enteric fermentation and manure management (indicator n_3) revealed that smaller farms (less than 20 ha UAA) contributed the least to thermal air pollution in 2003 and 2012. Farms of 100 ha UAA or over were the biggest source of the thermal air pollution with the CH_4 gases. Moreover, the GHG emission gap between the observed farm size classes increased

Table 6. Normalized values of economic indicators by the family farm size classes in 2003 and 2012 years

Farm size classes of UAA (ha)	Productivity			Solvency	Farm income	Fixed capital formation	Farm diversification	Farm risk management
	labour e_1	capital e_2	land e_3	e_4	e_5	e_6	e_7	e_8
				2003				
> 10 ha	0.14 *(0.12;0.16)*	0.26 *(0.15;0.36)*	0.48 *(0.35;0.62)*	0.03 *(0.02;0.03)*	0.07 *(0.06;0.07)*	0.18 *(0.08;0.28)*	0.07 *(0.03;0.17)*	0.34 *(0.18;0.48)*
10–20 ha	0.16 *(0.14;0.19)*	0.26 *(0.21;0.31)*	0.46 *(0.38;0.53)*	0.05 *(0.02;0.07)*	0.07 *(0.06;0.08)*	0.12 *(0.10;0.14)*	0.12 *(0.02;0.21)*	0.24 *(0.13;0.34)*
20–30 ha	0.15 *(0.13;0.17)*	0.21 *(0.18;0.24)*	0.38 *(0.36;0.41)*	0.06 *(0.02;0.09)*	0.07 *(0.06;0.07)*	0.11 *(0.10;0.11)*	0.06 *(0.00;0.12)*	0.19 *(0.09;0.27)*
30–40 ha	0.20 *(0.17;0.23)*	0.27 *(0.23;0.30)*	0.44 *(0.40;0.48)*	0.07 *(0.04;0.11)*	0.08 *(0.07;0.09)*	0.13 *(0.12;0.15)*	0.05 *(0.00;0.10)*	0.15 *(0.09;0.20)*
40–50 ha	0.22 *(0.17;0.23)*	0.28 *(0.24;0.31)*	0.44 *(0.39;0.48)*	0.10 *(0.04;0.15)*	0.10 *(0.07;0.13)*	0.13 *(0.10;0.17)*	0.08 *(0.00;0.16)*	0.15 (0.08;0.21)
50–100 ha	0.26 *(0.24;0.29)*	0.30 *(0.27;0.32)*	0.43 *(0.40;0.48)*	0.17 *(0.13;0.21)*	0.11 *(0.09;0.11)*	0.15 *(0.14;0.16)*	0.05 *(0.02;0.08)*	0.11 *(0.07;0.15)*
100–150 ha	0.32 *(0.27;0.37)*	0.30 *(0.26;0.33)*	0.43 *(0.42;0.45)*	0.18 *(0.13;0.24)*	0.12 *(0.10;0.15)*	0.17 *(0.15;0.20)*	0.08 *(0.03;0.13)*	0.10 *(0.06;0.15)*
≤ 150 ha	0.47 *(0.42;0.53)*	0.34 *(0.31;0.37)*	0.45 *(0.42;0.47)*	0.29 *(0.22;0.35)*	0.26 *(0.20;0.32)*	0.19 *(0.17;0.21)*	0.07 *(0.04;0.11)*	0.12 *(0.08;0.16)*
Total	0.28 *(0.26;0.29)*	0.29 *(0.28;0.30)*	0.44 *(0.42;0.45)*	0.15 *(0.13;0.17)*	0.12 *(0.11;0.14)*	0.15 *(0.15;0.16)*	0.07 *(0.05;0.08)*	0.15 *(0.13;0.17)*
$F_{(7.442)}$	27.2	4.3	1.3	9.6	19.3	6.1	0.6	4.1
Significance	***	***	****	***	***	***	****	***
				2012				
> 10 ha	0.17 *(0.15;0.20)*	0.34 *(0.23;0.45)*	0.63 *(0.50;0.77)*	0.12 *(0.00;0.24)*	0.10 *(0.07;0.14)*	0.37 *(0.26;0.48)*	0.14 *(0.01;0.26)*	0.38 *(0.22;0.53)*
10–20 ha	0.16 *(0.15;0.18)*	0.32 *(0.26;0.38)*	0.54 *(0.47;0.61)*	0.08 *(0.01;0.15)*	0.09 *(0.07;0.11)*	0.31 *(0.24;0.38)*	0.09 *(0.00;0.18)*	0.16 *(0.10;0.23)*
20–30 ha	0.19 *(0.17;0.21)*	0.35 *(0.30;0.41)*	0.55 *(0.51;0.60)*	0.14 *(0.07;0.21)*	0.09 *(0.08;0.10)*	0.30 *(0.27;0.33)*	0.06 *(0.00;0.12)*	0.14 *(0.08;0.20)*
30–40 ha	0.19 *(0.17;0.21)*	0.32 *(0.27;0.37)*	0.50 *(0.47;0.54)*	0.18 *(0.08;0.28)*	0.09 *(0.08;0.10)*	0.40 *(0.30;0.49)*	0.14 *(0.02;0.26)*	0.21 *(0.14;0.29)*
40–50 ha	0.22 *(0.19;0.24)*	0.32 *(0.28;0.35)*	0.52 *(0.49;0.55)*	0.11 *(0.04;0.18)*	0.11 *(0.09;0.12)*	0.32 *(0.27;0.37)*	0.02 *(0.00;0.03)*	0.26 *(0.18;0.34)*
50–100 ha	0.27 *(0.25;0.29)*	0.33 *(0.31;0.35)*	0.53 *(0.51;0.54)*	0.34 *(0.28;0.40)*	0.12 *(0.11;0.13)*	0.34 *(0.31;0.37)*	0.06 *(0.03;0.10)*	0.17 *(0.13;0.21)*
100–150 ha	0.34 *(0.29;0.39)*	0.35 *(0.30;0.39)*	0.56 *(0.53;0.60)*	0.40 *(0.29;0.50)*	0.19 *(0.15;0.22)*	0.41 *(0.33;0.48)*	0.05 *(0.01;0.09)*	0.15 *(0.09;0.20)*
≤ 150 ha	0.51 *(0.47;0.56)*	0.37 *(0.35;0.39)*	0.58 *(0.56;0.60)*	0.46 *(0.41;0.52)*	0.42 *(0.37;0.47)*	0.38 *(0.36;0.41)*	0.06 *(0.04;0.08)*	0.12 *(0.09;0.14)*
Total	0.31 *(0.30;0.33)*	0.34 *(0.33;0.36)*	0.55 *(0.54;0.56)*	0.30 *(0.27;0.33)*	0.20 *(0.18;0.22)*	0.36 *(0.34;0.37)*	0.07 *(0.05;0.09)*	0.17 *(0.15;0.19)*
$F_{(7.442)}$	43.9	1.3	3.6	16.0	43.8	2.4	1.6	6.3
Significance	***	****	***	***	***	*	****	***

all indicators e_1–e_8 have been normalized following the assumption that their actual maximum values are positive in terms of sustainability

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; ****$p > 0.05$

Bootstrapped 95% confidence intervals based on 1000 replications are reported in parentheses

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within the decade, i.e. from 13.8% to 32%. It should be noted that the calculation of the GHG emission indicator was obtained just from breeding animals. However, about one third of the Lithuanian farms do not breed animals, they are not the sources of CH_4 and N_2O gas emission as well. Moreover, livestock is not only the source of the thermal air pollution, but it also causes soil and water pollution with nitrogen. The livestock density (for more details, see indicator a_8, Table 2) was determined in the large-sized farms (150 ha UAA or over) in considered years (Table 7). The average normalized values of the energy use

Table 7. Normalized values of environmental indicators by the family farm size classes in 2003 and 2012 years

Farm size classes of UAA (ha)	Use of chemical fertilizers	Use of pesticides	GHG emission	Energy intensity	Agricultural biodiversity	Meadows and pastures	Livestock density	Environment-friendly farming
	n_1	n_2	n_3	n_4	n_5	n_6	n_7	n_8
2003								
> 10 ha	0.80 *(0.66;0.94)*	0.84 *(0.72;0.97)*	0.99 *(0.99;1.00)*	0.65 *(0.62;0.69)*	0.55 *(0.44;0.67)*	0.08 *(0.00;0.18)*	0.77 *(0.66;0.89)*	0.00 *(0.00;0.00)*
10–20 ha	0.84 *(0.78;0.91)*	0.88 *(0.81;0.95)*	0.98 *(0.97;0.99)*	0.64 *(0.63;0.65)*	0.67 *(0.60;0.74)*	0.13 *(0.05;0.20)*	0.78 *(0.71;0.85)*	0.11 *(0.01;0.20)*
20–30 ha	0.90 *(0.87;0.93)*	0.91 *(0.86;0.96)*	0.95 *(0.94;0.96)*	0.63 *(0.62;0.64)*	0.61 *(0.51;0.70)*	0.17 *(0.08;0.28)*	0.76 *(0.70;0.81)*	0.05 *(0.02;0.13)*
30–40 ha	0.87 *(0.82;0.91)*	0.92 *(0.88;0.96)*	0.93 *(0.91;0.94)*	0.61 *(0.59;0.64)*	0.64 *(0.57;0.71)*	0.11 *(0.05;0.17)*	0.76 *(0.71;0.81)*	0.04 *(0.00;0.10)*
40–50 ha	0.88 *(0.85;0.91)*	0.87 *(0.81;0.93)*	0.93 *(0.91;0.95)*	0.63 *(0.62;0.64)*	0.66 *(0.57;0.74)*	0.05 *(0.01;0.10)*	0.83 *(0.77;0.88)*	0.04 *(0.00;0.10)*
50–100 ha	0.83 *(0.80;0.85)*	0.86 *(0.83;0.90)*	0.90 *(0.88;0.91)*	0.63 *(0.62;0.64)*	0.65 *(0.61;0.69)*	0.05 *(0.02;0.08)*	0.83 *(0.81;0.86)*	0.04 *(0.01;0.07)*
100–150 ha	0.77 *(0.72;0.82)*	0.80 *(0.74;0.85)*	0.87 *(0.83;0.92)*	0.63 *(0.63;0.64)*	0.68 *(0.63;0.74)*	0.01 *(0.00;0.02)*	0.88 *(0.85;0.91)*	0.02 (0.00;0.05)
≤ 150 ha	0.71 *(0.67;0.75)*	0.73 *(0.67;0.78)*	0.88 *(0.83;0.93)*	0.63 *(0.62;0.63)*	0.77 *(0.73;0.81)*	0.03 *(0.02;0.06)*	0.93 *(0.91;0.96)*	0.01 *(0.00;0.04)*
Total	0.81 *(0.80;0.83)*	0.84 *(0.82;0.86)*	0.91 *(0.90;0.92)*	0.63 *(0.63;0.63)*	0.67 *(0.65;0.69)*	0.07 *(0.05;0.08)*	0.84 *(0.82;0.85)*	0.04 *(0.02;0.05)*
$F_{(7.442)}$	7.5	6.6	5.2	1.8	3.4	4.8	9.9	1.3
Significance	***	***	***	****	**	***	***	****
2012								
> 10 ha	0.67 *(0.53;0.80)*	0.60 *(0.46;0.75)*	0.99 *(0.99;0.99)*	0.45 *(0.42;0.48)*	0.64 *(0.53;0.75)*	0.21 *(0.07;0.35)*	0.74 *(0.63;0.86)*	0.00 *(0.00;0.00)*
10–20 ha	0.85 *(0.78;0.92)*	0.88 *(0.82;0.94)*	0.98 *(0.97;0.99)*	0.44 *(0.40;0.49)*	0.64 *(0.56;0.73)*	0.18 *(0.08;0.29)*	0.82 *(0.77;0.88)*	0.08 *(0.00;0.16)*
20–30 ha	0.90 *(0.84;0.96)*	0.92 *(0.86;0.99)*	0.94 *(0.93;0.96)*	0.46 *(0.43;0.49)*	0.61 *(0.52;0.70)*	0.13 *(0.05;0.20)*	0.79 *(0.72;0.86)*	0.18 *(0.06;0.30)*
30–40 ha	0.93 *(0.90;0.97)*	0.96 *(0.94;0.98)*	0.93 *(0.89;0.96)*	0.47 *(0.43;0.50)*	0.69 *(0.62;0.76)*	0.20 *(0.10;0.30)*	0.81 *(0.73;0.88)*	0.13 *(0.01;0.24)*
40–50 ha	0.93 *(0.88;0.97)*	0.95 *(0.91;0.98)*	0.92 *(0.90;0.95)*	0.44 *(0.44;0.45)*	0.56 *(0.46;0.66)*	0.13 *(0.05;0.21)*	0.84 *(0.79;0.89)*	0.21 *(0.09;0.34)*
50–100 ha	0.84 *(0.80;0.89)*	0.88 *(0.83;0.92)*	0.88 *(0.85;0.90)*	0.45 *(0.44;0.46)*	0.59 *(0.54;0.65)*	0.16 *(0.10;0.21)*	0.84 *(0.81;0.87)*	0.15 *(0.09;0.21)*
100–150 ha	0.81 *(0.74;0.89)*	0.83 *(0.76;0.90)*	0.75 *(0.67;0.82)*	0.45 *(0.44;0.45)*	0.71 *(0.64;0.79)*	0.14 *(0.05;0.23)*	0.81 *(0.75;0.86)*	0.08 *(0.00;0.16)*
≤ 150 ha	0.59 *(0.53;0.65)*	0.69 *(0.64;0.74)*	0.78 *(0.72;0.84)*	0.44 *(0.44;0.45)*	0.77 *(0.74;0.80)*	0.04 *(0.01;0.06)*	0.90 *(0.87;0.93)*	0.10 *(0.05;0.15)*
Total	0.78 *(0.75;0.80)*	0.82 *(0.80;0.85)*	0.86 *(0.84;0.88)*	0.45 *(0.44;0.45)*	0.67 *(0.64;0.69)*	0.12 *(0.10;0.15)*	0.84 *(0.83;0.86)*	0.12 *(0.10;0.15)*
$F_{(7.442)}$	17.6	14.4	9.3	1.1	7.0	3.6	4.4	1.7
Significance	***	***	***	****	***	***	***	****

indicators n_1–n_5 and n_7 have been normalized following the assumption that their actual minimal values are positive in terms of sustainability, where $n_{6,}$ = the highest, n_8 = the qualitative indicator measured by scores within the interval [0; 1]

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; ****$p > 0.05$

Bootstrapped 95% confidence intervals based on 1000 replications are reported in parentheses

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intensity (indicator n_4, Table 2) were considerably lower in the year 2012 than in the year 2003. This indicated a considerable increase in energy intensity within the decade.

The average normalized values of positive variables in the environmental terms such as the agricultural biodiversity, the share of meadows and pastures, organic farming and the participation in agri-environmental schemes (see indicators n_5 n_6 and n_8, Table 2) were fairly different across the observed farm size classes. The highest level of crop biodiversity, as measured by the Simpson's diversity index,

Table 8. Normalized values of social indicators by the family farm size classes in 2003 and 2012 years

Farm size classes of UAA	Family work s_1	Jobs on farm s_2	Wage ratio on farm s_3	Pluriactivity s_4	Workload exceeded s_5	Farming continuity s_6	Farmer's age s_7
				2003			
> 10 ha	0.93 *(0.85;1.01)*	0.10 *(0.06;0.15)*	0.03 *(0.00;0.08)*	0.60 *(0.36;0.83)*	1.00 *(1.00;1.00)*	0.48 *(0.42;0.53)*	0.50 *(0.50;0.50)*
10–20 ha	0.93 *(0.87;0.99)*	0.13 *(0.10;0.17)*	0.05 *(0.00;0.09)*	0.58 *(0.41;0.74)*	0.97 *(0.92;1.00)*	0.45 *(0.36;0.53)*	0.46 *(0.38;0.55)*
20–30 ha	0.96 *(0.92;1.00)*	0.14 *(0.11;0.18)*	0.01 *(0.00;0.04)*	0.49 *(0.30;0.64)*	0.99 *(0.96;1.00)*	0.43 *(0.37;0.49)*	0.49 *(0.40;0.57)*
30–40 ha	0.95 *(0.92;0.99)*	0.15 *(0.13;0.17)*	0.07 *(0.01;0.12)*	0.54 *(0.40;0.69)*	0.99 *(0.97;1.00)*	0.50 *(0.42;0.58)*	0.50 *(0.43;0.57)*
40–50 ha	0.89 *(0.82;0.95)*	0.16 *(0.13;0.19)*	0.11 *(0.02;0.19)*	0.36 *(0.20;0.52)*	0.99 *(0.96;1.00)*	0.53 *(0.44;0.61)*	0.49 *(0.42;0.56)*
50–100 ha	0.88 *(0.86;0.92)*	0.19 *(0.16;0.021)*	0.14 *(0.09;0.19)*	0.39 *(0.31;0.48)*	0.92 *(0.89;0.96)*	0.62 *(0.57;0.67)*	0.54 *(0.50;0.58)*
100–150 ha	0.81 *(0.75;0.87)*	0.22 *(0.18;0.26)*	0.29 *(0.20;0.38)*	0.27 *(0.15;0.38)*	0.93 *(0.89;0.98)*	0.74 *(0.68;0.81)*	0.58 *(0.53;0.62)*
≤ 150 ha	0.64 *(0.57;0.71)*	0.31 *(0.26;0.36)*	0.29 *(0.22;0.36)*	0.28 *(0.18;0.38)*	0.95 *(0.92;0.99)*	0.86 *(0.81;0.91)*	0.54 *(0.51;0.58)*
Total	0.85 *(0.83;0.87)*	0.20 *(0.18;0.21)*	0.15 *(0.13;0.18)*	0.40 *(0.35;0.44)*	0.95 *(0.94;0.97)*	0.62 *(0.60;0.65)*	0.52 *(0.50;0.54)*
$F_{(7.442)}$	16.2	11.8	9.4	3.4	2.1	21.5	1.7
Significance	***	***	***	**	*	***	****
				2012			
> 10 ha	0.83 *(0.70;0.95)*	0.14 *(0.05;0.23)*	0.07 *(0.00;0.14)*	0.74 *(0.55;0.93)*	1.00 *(1.00;1.00)*	0.46 *(0.39;0.52)*	0.46 *(0.39;0.52)*
10–20 ha	0.92 *(0.86;0.98)*	0.08 *(0.06;0.10)*	0.06 *(0.00;0.11)*	0.82 *(0.68;0.96)*	1.00 *(1.00;1.00)*	0.45 *(0.39;0.52)*	0.48 *(0.40;0.57)*
20–30 ha	0.91 *(0.85;0.97)*	0.09 *(0.06;0.12)*	0.07 *(0.00;0.13)*	0.72 *(0.57;0.88)*	0.97 *(0.93;1.00)*	0.46 *(0.40;0.52)*	0.50 *(0.41;0.59)*
30–40 ha	0.97 *(0.94;1.00)*	0.07 *(0.06;0.08)*	0.02 *(0.00;0.05)*	0.75 *(0.59;0.91)*	0.98 *(0.95;1.00)*	0.53 *(0.45;0.61)*	0.55 *(0.46;0.63)*
40–50 ha	0.93 *(0.87;0.98)*	0.09 *(0.08;0.11)*	0.06 *(0.00;0.11)*	0.58 *(0.41;0.74)*	0.93 *(0.87;0.98)*	0.53 *(0.49;0.56)*	0.73 *(0.64;0.81)*
50–100 ha	0.89 *(0.86;0.93)*	0.11 *(0.08;0.13)*	0.12 *(0.08;0.16)*	0.63 *(0.55;0.72)*	0.96 *(0.94;0.99)*	0.61 *(0.57;0.66)*	0.59 *(0.55;0.64)*
100–150 ha	0.66 *(0.56;0.75)*	0.22 *(0.17;0.26)*	0.33 *(0.25;0.42)*	0.59 *(0.43;0.76)*	0.96 *(0.91;1.00)*	0.69 *(0.61;0.71)*	0.57 *(0.51;0.63)*
≤ 150 ha	0.47 *(0.42;0.52)*	0.34 *(0.29;0.38)*	0.44 *(0.40;0.47)*	0.48 *(0.39;0.57)*	0.98 *(0.97;0.99)*	0.81 *(0.76;0.85)*	0.54 *(0.50;0.58)*
Total	0.76 *(0.73;0.79)*	0.18 *(0.16;0.20)*	0.20 *(0.18;0.23)*	0.62 *(0.57;0.66)*	0.97 *(0.96;0.98)*	0.63 *(0.60;0.65)*	0.56 *(0.54;0.58)*
$F_{(7.442)}$	46.7	26.2	40.7	3.2	1.9	20.4	4.7
Significance	***	***	***	**	****	***	***

quantitative indicators s_1–s_3 have been normalized following the assumption that their actual maximum values are positive in terms of sustainability, and qualitative indicators s_4–s_7 measured by scores within the interval [0; 1]

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; ****$p > 0.05$

Bootstrapped 95% confidence intervals based on 1000 replications are reported in parentheses

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was achieved in the largest farm size class (150 ha UAA or over) in both considered years, whereas the lowest level was established in the small-sized farms (less than 10 ha UAA) and the medium-sized farms (from 40 to 100 ha UAA) in 2003 and 2012, respectively. Consequently, the smaller farms were found to have a more beneficial effect on the conservation of agricultural biodiversity due to their larger share of meadows and pastures in UAA compared to the large-sized farms (Table 7).

Agri-environmental measures of the Rural Development Programmes (RDP) encourage farmers for the nature conservation and environmental protection in agricultural areas. The average normalized values of the indicator referring to organic farming, the participation in agri-environmental and the food quality schemes were considerably higher in smaller farms (except for the farm size class less than 10 ha UAA) than in the larger farms in 2003 and 2012. Moreover, in 2012 the normalized value of this indicator was considerably higher in all farm size classes except for the first two than in 2003. This finding suggests that the farms became more involved in the agri-environmental programmes as an effect of the EU RDP implementation in Lithuania (Table 7).

Table 8 presents the average normalized values of social indicators taking into account that the indicators s_1, s_4, s_6 and s_7 (for more details, see Table 3) are assigned to the internal farm's social needs related to the well-being of the farmer and his/her family, whereas the indicator s_3 is assigned to the external needs related to the community well-being. Therefore, the indicators s_2 and s_5 are assigned to both mentioned needs. Farming exclusively based on the family workforce was observed in the medium-sized farms, i.e. from 20 to and from 30 to 50 ha UAA in 2003 and 2012, respectively. The lowest share of the family workforce was established in farms of 150 ha UAA or over in the considered years. In addition, the growing trend towards the hired workforce was found in large-sized farms.

The pluriactivity of the farmer and other family members increases the farm household income and improves the living conditions, as well reduces the family risk caused by the fluctuations of the agricultural income, thus contributing to the social stability of the farm. The average normalized values of the off-farm income were significantly higher in 2012 than in 2003. The most significant effect of this income was observed in small-sized farms less than 20 ha UAA and from 10 to 20 ha UAA in 2003 and 2012, respectively. As an indication of the risk of the abandonment of agricultural activity (indicator s6), the larger-sized was the farm, the higher the continuity of farming was established. Moreover, a more favourable farmer's age (indicator s_7) was determined in the large-sized farms in both considered years.

The developed social indicators related to the external and internal-external social needs (for more details, see indicators s2, s3 and s5, Table 3) define the contribution of the farm to the social development of the community within the local, regional and broader context. In the terms of job creation, the highest rates were established in the farm classes of 150 ha UAA or over and the lowest rates on less than 10 ha and from 30 to 40 ha UAA in 2003and 2012, respectively. Moreover, the gap in these indicators normalized values between the reported farm size classes was 5 fold in 2012, compared to 3 fold in 2003. The highest wage ratio on farm (indicator s_3) found in farms size classes of 100 ha UAA or over, and the lowest ratio in the medium-sized farms, i.e. from 20 to 30 ha UAA and from 30 to 40 ha UAA in 2003 and 2012, respectively (Table 8).

Table 9 provides the average values of the FRSI and the economic, environmental and social sub-indices according to the farm size classes. The average values of the economic sub-index fell within the interval of the low sustainability interval in the most farm size classes in both considered years, except for the largest-sized class in 2012, the average value of which concentrated at the bottom boundary of the medium sustainability interval. The medium variation of the economic sub-indices across the farm size classes was determined, and made 17.0 % in 2003 and 15.7% in 2012. This explains that the economic state is rather different in the considered farms size classes.

The average values of the environmental sub-index of the most of the analysed farm sizes fell within the high sustainability interval and concentrated at its bottom boundary, except in 2012 for the smallest-sized and large-sized farm classes (100 ha UAA or over), the values of which concentrated closer to the upper boundary of the medium sustainability interval. The low variation of this sub-index across the analysed farm size classes was determined (3.7% and 9.3 % in 2003 and 2012, respectively). This shows that although the environmental situation in family farms is rather similar, the differences increased within the decade. The best agri-environmental state was determined in the mid-sized family farms (i.e. from 20 to 30 ha UAA and from 30 to 40 ha UAA in

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2003 and 2012, respectively). By contrast, the worst agri-environmental state was found in the largest-sized farms class in 2003 and in the smallest-sized farms class in 2012 as well.

The average values of the social sub-index fell within the medium sustainability interval and concentrated in its middle. The low variation between the social sub-index values of farm size classes was determined (4.5 % and 3.7% in 2003 and 2012, respectively), i.e. it shows the similar social state in the considered farms size classes. Nonetheless, the social state in the larger-sized farms (50 ha UAA or over) was better than in the small-sized farms in the considered years, as shown in Table 9.

The average values of the FRSI in the analysed farm size classes fell within the medium sustainability interval and concentrated just below its middle in both considered years. The observed FRSI variation between farm size classes was low (2.0% and 3.4% in 2003 and 2012, respectively). The average relative sustainability state across the farms size classes was similar. Nonetheless, in 2003, the best average relative sustainability state was observed in the largest-sized farms, while in 2012, the best average relative sus-

Table 9. Relative farm sustainability index and sub-indexes by the family farm size classes in 2003 and 2012 years

Farm size classes of UAA	Economic sub-index	Environmental sub-index	Social sub-index	Sustainability index (FRSI)
		2003		
> 10 ha	0.21 *(0.16;0.26)*	0.69 *(0.63;0.74)*	0.47 *(0.45;0.49)*	0.45 *(0.43;0.46)*
10–20 ha	0.20 *(0.17;0.22)*	0.72 *(0.69;0.76)*	0.47 *(0.45;0.50)*	0.46 *(0.45;0.47)*
20–30 ha	0.16 *(0.14;0.18)*	0.73 *(0.71;0.75)*	0.47 *(0.45;0.49)*	0.45 *(0.44;0.46)*
30–40 ha	0.18 *(0.16;0.20)*	0.72 *(0.69;0.74)*	0.49 *(0.47;0.51)*	0.46 *(0.45;0.46)*
40–50 ha	0.20 *(0.17;0.22)*	0.72 *(0.70;0.73)*	0.47 *(0.45;0.50)*	0.46 *(0.45;0.47)*
50–100 ha	0.20 *(0.19;0.22)*	0.70 *(0.64;0.71)*	0.50 *(0.49;0.51)*	0.46 *(0.45;0.47)*
100–150 ha	0.22 *(0.21;0.24)*	0.67 *(0.65;0.69)*	0.53 *(0.51;0.54)*	0.47 *(0.45;0.47)*
≤ 150 ha	0.28 *(0.26;0.30)*	0.66 *(0.64;0.67)*	0.51 *(0.50;0.53)*	0.48 *(0.46;0.48)*
Total	0.21 *(0.20;0.22)*	0.69 *(0.69;0.70)*	0.50 *(0.49;0.50)*	0.46 *(0.46;0.47)*
$F_{(7.442)}$	11.6	6.4	3.5	1.8
Significance	***	***	***	****
Standard deviation	0.04	0.03	0.02	0.01
Coefficient of variation	17.0	3.7	4.5	2.0
		2012		
> 10 ha	0.30 *(0.24;0.36)*	0.59 *(0.53;0.66)*	0.47 *(0.44;0.49)*	0.45 *(0.43;0.47)*
10–20 ha	0.23 *(0.21;0.27)*	0.71 *(0.68;0.74)*	0.49 *(0.47;0.50)*	0.47 *(0.45;0.49)*
20–30 ha	0.24 *(0.22;0.26)*	0.73 *(0.70;0.76)*	0.48 *(0.46;0.50)*	0.48 *(0.46;0.49)*
30–40 ha	0.27 *(0.23;0.31)*	0.75 *(0.73;0.78)*	0.50 *(0.49;0.52)*	0.50 *(0.48;0.52)*
40–50 ha	0.24 *(0.23;0.27)*	0.74 *(0.72;0.77)*	0.50 *(0.49;0.52)*	0.49 *(0.48;0.51)*
50–100 ha	0.28 *(0.26;0.29)*	0.70 *(0.68;0.72)*	0.51*(0.50;0.52)*	0.49 *(0.48;0.50)*
100–150 ha	0.31 *(0.28;0.34)*	0.66 *(0.63;0.70)*	0.52 *(0.49;0.54)*	0.49 *(0.47;0.51)*
≤ 150 ha	0.36 *(0.35;0.38)*	0.60 *(0.57;0.62)*	0.52 *(0.50;0.53)*	0.49 *(0.48;0.50)*
Total	0.30 *(0.29;0.31)*	0.67 *(0.66;0.69)*	0.50 *(0.50;0.51)*	0.49 *(0.48;0.49)*
$F_{(7.442)}$	18.0	18.3	3.4	3.6
Significance	***	***	*	**
Standard deviation	0.04	0.06	0.02	0.02
Coefficient of variation	15.7	9.3	3.7	3.4

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; ****$p > 0.05$

Bootstrapped 95% confidence intervals based on 1000 replications are reported in parentheses

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Annex. Descriptive statistics of sustainability indicators in the Lithuanian FADN sample in 2003 and 2012

Economic indicators

Descriptive statistics	Labour productivity (thou. EUR/AWU)	Capital productivity	Land productivity (thou. EUR/ha)	Solvency	Farm income (thou. EUR/FAWU)	Fixed capital formation (thou. EUR/ha)	Farm diversification (per cent)	Farm risk management (per cent)
2003								
Min	−5.4	−0.03	−0.6	0.61	−12.3	−0.9	0.0	0.0
Max	42.4	0.20	1.2	675.5	199.8	0.7	1.0	6.2
Mean	7.8	0.04	0.2	48.8	14.1	0.1	0.1	0.9
SD	9.3	0.03	0.2	119.8	30.7	0.2	0.2	1.4
2012								
Min	−13.3	−0.05	−1.1	0.38	−20.5	−0.4	0.3	0.0
Max	90.0	0.25	1.6	252.9	275.0	1.3	0.0	15.6
Mean	19.1	0.05	0.4	18.0	39.6	0.2	15.2	2.7
SD	21.4	0.04	0.4	42.4	63.9	0.3	1.0	3.2

Environmental indicators

Descriptive statistics	Use of chemical fertilizers (kg/ha)	Use of pesticides (EUR/ha)	GHG emission (tonnes CO_2 -eq.)	Energy intensity	Biodiversity on a farm	Meadows and pastures (per cent of UAA)	Livestock density (LSUs/ha)	Environment-friendly farming (score)
2003								
Min	0.0	0.0	0.0	−4.2	0.1	0.0	0.0	0.0
Max	1512.7	107.3	817.3	7.4	1.0	97.8	1.8	1.0
Mean	282.8	17.1	71.6	0.1	0.4	6.5	0.3	–
SD	310.6	22.1	106.5	0.6	0.2	17.3	0.3	–
2012								
Min	0.0	0.0	0.0	−4.4	0.1	0.0	0.0	0.0
Max	1450.9	179.1	690.7	2.4	1.0	100.0	1.9	1.0
Mean	322.4	32.0	93.7	0.0	0.4	12.4	0.3	–
SD	408.3	45.8	152.0	0.5	0.2	25.7	0.3	–

Social indicators

Descriptive statistics	Family work (per cent)	Jobs on farm (FTE)	Wage ratio on farm (per cent)	Pluriactivity (score)	Workload exceeded (score)	Continuity of farming (score)	Farmer's age (score)
2003							
Min	3.1	0.0	0.0	0.0	0.0	0.0	0.0
Max	100.0	70.4	1.0	1.0	1.0	1.0	1.0
Mean	85.5	10.8	0.4	–	–	–	–
SD	23.2	19.4	0.5	–	–	–	–
2012							
Min	4.4	0.0	0.0	0.0	0.5	0.0	0.0
Max	100.0	104.3	1.0	1.0	1.0	1.0	1.0
Mean	77.2	21.2	0.6	–	–	–	–
SD	29.1	27.4	0.5	–	–	–	–

tainability state was achieved in the medium-sized farms (from 30 to 40 ha UAA).

CONCLUSIONS

The index for the agricultural sustainability assessment at farm level was developed. In this study, the farm relative sustainability index (FRSI) was composed of three sub-indices that correspond to three dimensions of sustainable development, i.e. economic, environmental and social. The FRSI allowed for assessing of the individual farm's relative sustainability by comparing the best results achieved in the total farms. Consistently, three sets of 23 indicators using the FADN database were developed. It should be noted, however, that the FRSI is intended to assess the relative sustainability of the family farm. In order to apply the FRSI to the corporate farms sustainability assessment, the composition of the social sub-index is required to be adapted for the social internal and external needs of these farms. This would require to exclude the indicators related to the family-specific needs and attributes (such as the family work, pluriactivity, farmer's age) and to modify the indicators related to the risk of abandonment of agricultural activity and to include new indicators related to the social responsibility of corporate farms.

The Lithuanian case analysis suggested that certain measures for strengthening the farms sustainability were necessary as the FRSI fell within the medium sustainability interval in 2003 and 2012. The average values of the FRSI in the analysed farm size classes fell within the medium sustainability interval and the observed index variation between farm size classes was low. The average relative sustainability state across the farms size classes was similar in comparison with the best sustainability state achieved in Lithuanian farms in the considered years. Nonetheless, in 2003, the best average sustainability state was observed in the large-sized farms classes, while in 2012, the best average sustainability state was achieved by the medium-sized farms classes. The average values of the economic sub-index fell within the interval of low sustainability and the medium variation of economic sub-indices across the farm size classes was determined. The observed state explained by the scale of economy and the best results were achieved in the largest-size farm class. The average values of the environmental sub-index fell within the high sustainability interval and the low variation of this

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sub-index across the analysed farm size classes was determined. It should be noted, that the differences of the farm environmental state increased within the decade. The average values of the social sub-index fell within the medium sustainability interval and the low variation between the social sub-index values were established. The performed social situation was similar in the considered farms size classes. Nonetheless, the social state in the large-sized farms was better than that in the small-sized farms.

The farm sustainability assessment by the FRSI allows for not only comparing the common relative sustainability state of family farms in the context of the best results achieved at the national level, but also determining the economic, environmental, and social issues of a farm or a group of farms. For example, the lowest FRSI was determined in the smallest-sized farm class in 2012. A detailed analysis of the normalized values of economic, environmental, and social indicators showed that this size class of farms faced the highest risk of abandonment of agricultural activity and other issues such as the unfavourable farmers' age, the lowest or one of the lowest labour productivity, the lowest level of the family farm income, the highest intensity of the fertilizer and pesticide use, the highest livestock density, the most passive participation in the agri-environmental programmes. Certain long-term issues like the low labour productivity level, the low family income, the high livestock density were determined for the years 2003 and 2012 as well.

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