AGRI-ENVIRONMENTAL FOOTPRINT INDEX OF FAMILY FARMS USING FADN DATA: METHODOLOGY AND APPLICATION

Vida Dabkienė
Lithuanian institute of agrarian economics

This project has received funding from European Social Fund (project No 09.3.3-LMT-K-712-01-0007) under grant agreement with the Research Council of Lithuania (LMTLT).

THE TOPICALITY

1. Towards a methodology for the environmental assessment of agriculture

- *The environmental performance of agriculture is manifold, therefore to capture important aspects of farm environmental performance a list of criteria and indicators have been proposed to reveal the situation in the country. Having many indicators, there is a problem to view the main picture of environmental performance and to track the environmental changes influenced by policy*;
- *Farmers adopt new technologies and practices to deal with climate change, protect and preserve the environment, therefore it is important to determine how and how well farmers mitigate and adapt to climate change and to track their achievements ;*
- *EU Farm Accountancy Data Network (FADN) has been employed by researchers for farm environmental performance analyses across EU countries (Westbury et al. 2011; Gerrard et al. 2012; Kołoszko-Chomentowska et al. 2015). However, the devised indictors differ and thus limit the comparison of results derived by different researchers. Herewith, the derived set of indicators disclose the attempts to cover activity areas of farms environmental performance;*
- *Most indicators of agricultural environmental performance are country-scale and this leads to limited analysis within farm groups in terms of farming type and size.*

THE TOPICALITY

2. Towards the current environmental situation of Lithuanian agricultural sector which faces with numerous challenges in achieving environmental sustainability:

- *Lithuania is running an ecological deficit as its Ecological Footprint exceeds its bio-capacity. Despite the fact that this deficit is small (0.4 gha), Lithuania is the only country with an ecological deficit among Baltic countries. Lithuania is losing the image of "green country" and there are the reasons behind this state:*
- *Lithuanian agriculture between 2005 and 2018 saw a 3.3% increase of GHG emissions and the latter sector remained responsible for 21.1% of the total national GHG emission in 2018 (LNIR 2020). Agriculture is the second most significant source and accounted for 21.1% of the total emissions in 2018;*
- *production of renewable energy from agriculture per ha of UAA was 3.7 times lower than in the EU-28 on average in 2016;*
- *in 2018 as compared to 2008, the use of inorganic fertilizers has increased by 34.8% The N surplus per ha of UAA was found up to 27.2 kg in 2018;*
- *in 2018 as compared to 2011, the sales of fungicides and insecticides increased by 87.2% and 114.8%, respectively;*
- *the agricultural biodiversity is declining, it is demonstrated by the common farmland bird index decrease by 15 percentage points in 2018, as compared to 2008.*

THE TOPICALITY

3. Towards the environmental performance assessment of Lithuanian family farms

In spite of the importance of the assessment of Lithuanian farms' environmental performance there has been relatively little research devoted to this topic. The results of this is that the farm scale data on environmental performance is limited and to collect data is costly and time-consuming. On the other hand, FADN readily available farm scale data provides a range of information on environmental outcomes, though the researchers (Koloszko-Chomentowska et al. 2015; Volkov, Melnikienė 2017; Volkov et al. 2020) employed the distinct indicators to analyze the environmental performance of Lithuanian farms.

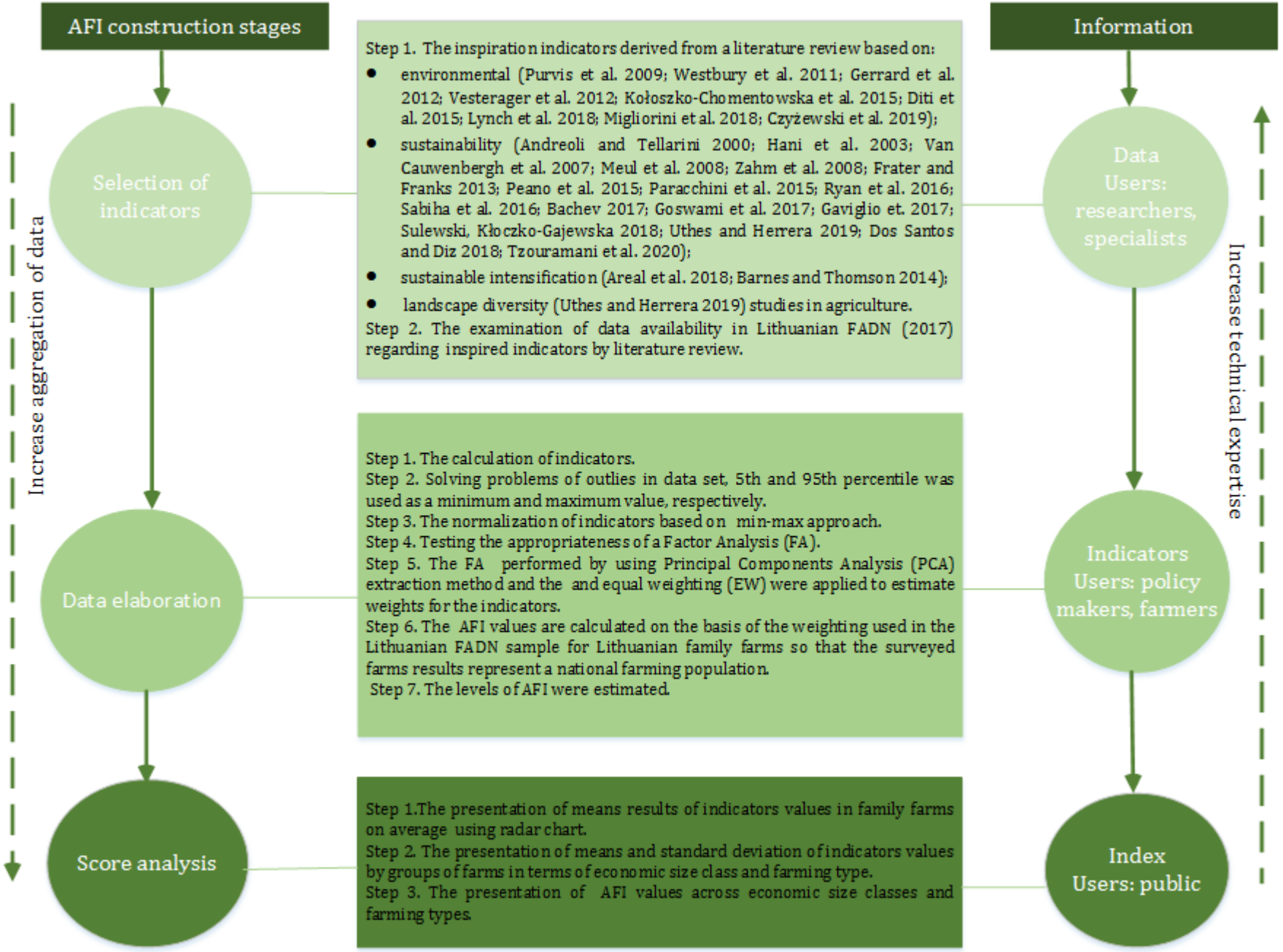
RESEARCH AIM

to assess the farm-scale environmental performance using Agri-environmental Footprint Index (AFI) and

1) to reveal differences within farms in terms of their specialization and economic size;

2) to test whether the presented methodology could be used routinely for policy purposes.

MATERIALS AND METHODS: index construction stages



MATERIALS AND METHODS: are there indicators for farm-scale agri-environmental performance assessment?

Components	Variable	Indicator	Data sources
Agricultural practices	Use of fertilizers	Amount of chemical fertilizers / Hectare of UAA	FADN variables: SE296; SE297; SE298; SE025
	Use of crop protection	Crop protection costs / Hectare of UAA	FADN variables: SE300; SE025
	GHG emissions	GHG emission per farm	Lithuanian FADN variables, IPCC guidelines (2006) and LNIR (2019)
Energy	Energy intensity	Energy costs / Total output	FADN variables: SE345; SE131
Diversity	Biodiversity	Shannon Evenness Index	Lithuanian FADN primary data on area of land use elements
Organisation of spaces	Meadows and pastures	Hectare of meadows and pastures / Hectare of UAA	Table 1 in Lithuanian FADN 2017
	Livestock density	Livestock units / Hectare of UAA	FADN variables: SE080; SE025
	Wooded area	Hectare of wooded area / Farm size in hectare	Table 1 in Lithuanian FADN 2017
	Accessibility	Output from agro-tourism	Lithuanian FADN primary data on output from agro-tourism
Natural resources	Environment-friendly farming	Organic farming subsidies and Natura 2000 payments / Total subsidies-excluding on investment	Table 9 in Lithuanian FADN 2017; Lithuanian FADN primary data on payments related to Natura 2000; FADN variable SE605
	Water consumption	Water costs / Total output	Lithuanian FADN primary data on water costs, FADN variable SE131
Farmer's agricultural skills	Education	Farmer' level of education	Lithuanian FADN primary data

MATERIALS AND METHODS

The method of min-max normalization that allows convert indicators to values between 0 (laggard) and 1 (leader) using maximum and minimum values of reference was applied to quantitative indicators.
Equation 1 is employed for indicators which an increase in value acts positively in terms of environmental performance and the equation 2 is employed for indicators whose increasing values has a negative impact on farms‘ agri-environmental performance (OECD, 2008):

$$I_{N,it}^{+} = \frac{I_{A,it}^{+} - I_{min,t}^{+}}{I_{max,t}^{+} - I_{min,t}^{+}};$$

(1): *accessibility, wooded area and meadows and pastures*

$$I_{N,it}^{-} = \frac{I_{max,t}^{-} - I_{A,it}^{-}}{I_{max,t}^{-} - I_{min,t}^{-}};$$

(2*): use of fertilizers, use of crop protection; GHG emissions; energy intensity; water consumption, livestock density*

The qualitative indicator “Accessibility ‘” was normalized by ranking, where the maximum value equalled to 1 (when the farm generated output from agro-tourism) and minimum value equalled to 0 (when the farm did generated output from agro-tourism).
Indicator “Education”: maximum value equalled to 1 (full agricultural training), the average value equalled to 0.5 (basic training) and the minimum value equalled to 0 (practical experience only).

MATERIALS AND METHODS

The principal component-based factor analysis followed by Varimax rotation was performed to obtain the weight for each indicator. Four components with eigenvalues greater than 1.0 were identified and the cumulative percentage of variance of these components accounted for a total of 48.62% of the overall variance. The rotated component loading matrix and proportion of variance were used to obtain the indicators' weight.

Principal components of the PCA on the agri-environmental performance indicators

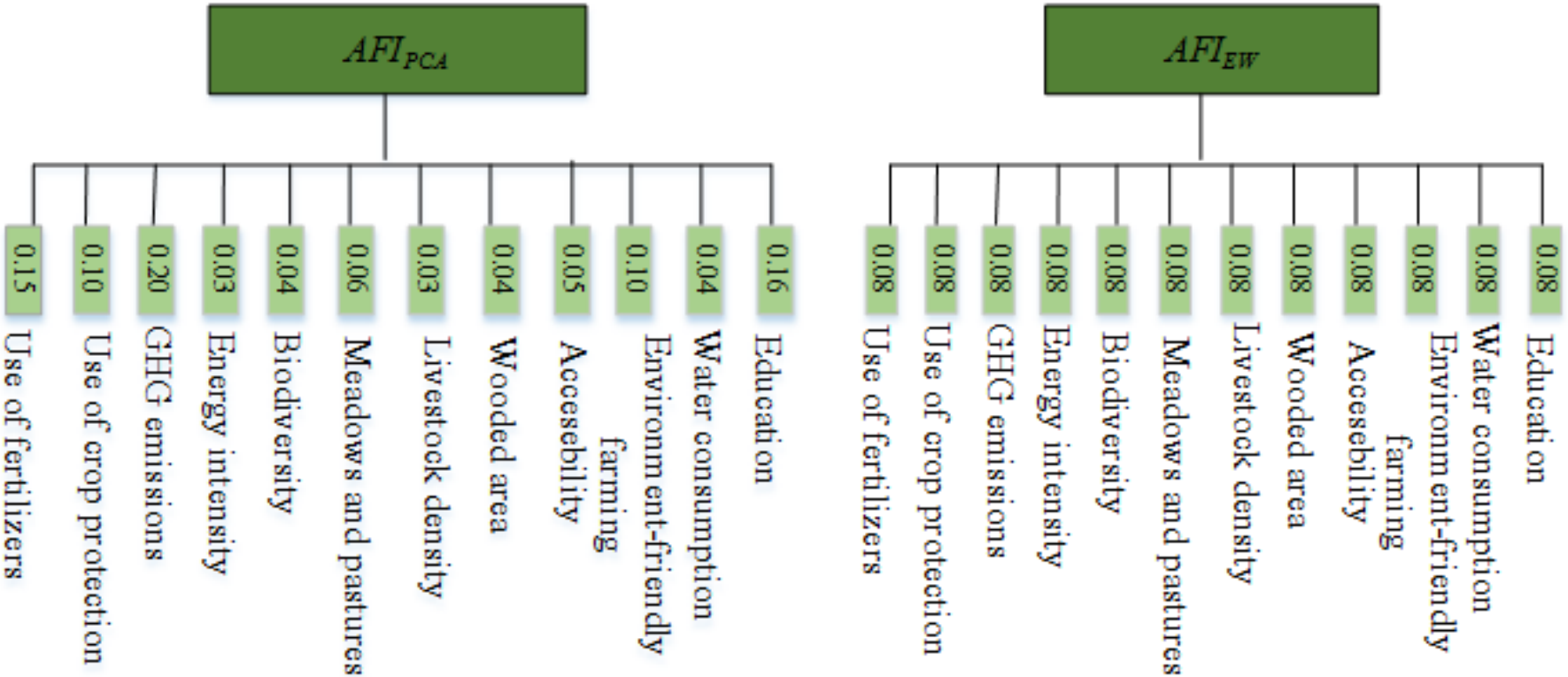
Variable	Components			
	1	2	3	4
Use of fertilizers	**0.587**	-0.474	-0.419	0.028
Use of crop protection	0.478	**-0.491**	-0.386	0.026
GHG emissions	**0.688**	-0.013	0.104	-0.083
Energy intensity	-0.271	0.292	-0.152	**0.562**
Biodiversity	0.307	0.290	**-0.389**	0.355
Meadows and pastures	0.039	-0.045	**0.716**	-0.053
Livestock density	0.126	-0.028	**0.465**	0.129
Wooded area	-0.017	**0.480**	-0.204	-0.038
Accessibility	-0.205	0.159	-0.051	**-0.678**
Environment-friendly farming	0.098	**0.749**	0.042	0.036
Water consumption	-0.293	-0.037	0.166	**0.590**
Education	**0.622**	0.103	0.138	-0.044
% of Variance	18.14	11.74	9.75	8.99

$$W_{ij} = \frac{(factor\ loading_{ij})^2}{\text{eigenvalue}_j}$$

The squared factor loading represents the unit variance in the indicators explained by the corresponding factors, w shows the weight of indicator i in component j.

MATERIALS AND METHODS

Structure of AFI



The index was obtained through use of the following equation:

$$AFI = \sum_{i=1}^{n} W_i \times I^{+}_{N,it} + \sum_{i=1}^{n} W_i \times I^{-}_{N,it}$$

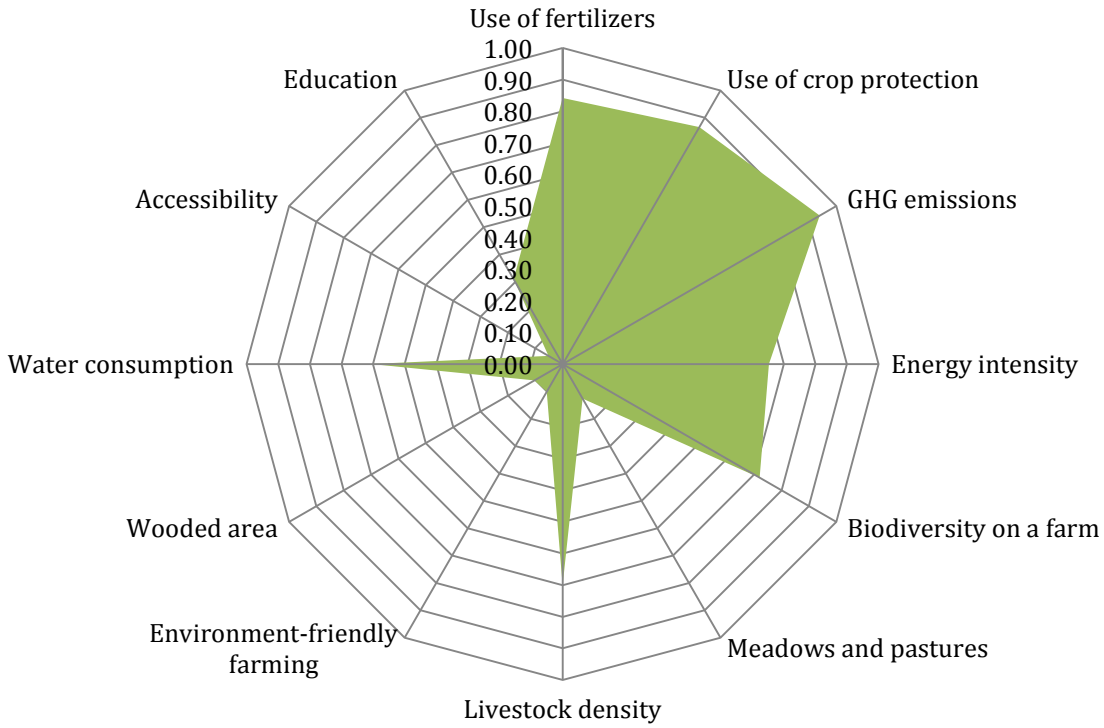
MATERIALS AND METHODS

The approach based on descriptive statistics proposed by Savickienė & Miceikienė (2018) was utilized to estimate the thresholds values of farms' AFI intervals.

AFI intervals and farms' sample distribution according to environmental performance level

AFI	Descriptive statistics				AFI intervals/environmental performance level		
	Minimum	Maximum	Mean	SD	Low *(% of farms)*	Medium *(% of farms)*	High *(% of farms)*
AFI_{PCA}	0.13	0.86	0.56	0.09	≤ 0.47 *(10.9)*	0.471–≤ 0.66 *(73.9)*	0.661–≤ 1 *(15.1)*
AFI_{EW}	0.29	0.80	0.50	0.08	≤ 0.42 *(13.7)*	0.421–≤ 0.58 *(71.1)*	0.581–≤ 1 *(15.2)*

THE RESEARCH RESULTS



Normalized values of agri-environmental performance indicators for Lithuanian family farms on average in 2017

The lowest values for the whole farms sample were obtained for indicators: *accessibility, environment-friendly farming, wooded area and meadows and pastures.*

Lithuanian family farms agri-environmental performance indicators values by economic farm size classes in 2017

Indicators	Economic size classes							Significance	CV
	4–< 8	8–< 15	15–< 25	25–< 50	50–< 100	100–< 250	>= 250		
Use of fertilizers	0.87 (0.20)	0.91 (0.17)	0.87 (0.25)	0.81 (0.24)	0.65 (0.32)	0.54 (0.33)	0.44 (0.31)	*	25.4
Use of crop protection	0.89 (0.21)	0.92 (0.16)	0.91 (0.20)	0.85 (0.23)	0.70 (0.32)	0.60 (0.33)	0.43 (0.35)	*	24.8
GHG emissions	0.98 (0.01)	0.97 (0.02)	0.95 (0.03)	0.92 (0.05)	0.84 (0.07)	0.67 (0.16)	0.26 (0.25)	*	32.7
Energy intensity	0.61 (0.29)	0.63 (0.29)	0.67 (0.24)	0.72 (0.21)	0.75 (0.22)	0.79 (0.19)	0.83 (0.12)	*	11.5
Biodiversity	0.73 (0.31)	0.69 (0.29)	0.74 (0.25)	0.73 (0.25)	0.75 (0.21)	0.77 (0.16)	0.74 (0.16)	*	3.3
Meadows and pastures	0.12 (0.19)	0.15 (0.27)	0.13 (0.22)	0.11 (0.19)	0.10 (0.21)	0.09 (0.18)	0.07 (0.15)	*	24.1
Livestock density	0.64 (0.33)	0.76 (0.25)	0.71 (0.27)	0.73 (0.31)	0.76 (0.30)	0.79 (0.32)	0.81 (0.32)	*	7.6
Wooded area	0.10 (0.28)	0.13 (0.28)	0.10 (0.25)	0.11 (0.24)	0.09 (0.21)	0.06 (0.14)	0.09 (0.16)	*	22.0
Accessibility	0.09 (0.28)	0.03 (0.18)	0.01 (0.17)	0.01 (0.10)	0.01 (0.10)	0.01 (0.10)	0.03 (0.16)	*	94.3
Environment-friendly farming	0.09 (0.26)	0.09 (0.26)	0.15 (0.31)	0.15 (0.33)	0.09 (0.27)	0.06 (0.23)	0.02 (0.13)	*	50.0
Water consumption	0.45 (0.39)	0.63 (0.31)	0.72 (0.26)	0.75 (0.26)	0.82 (0.20)	0.90 (0.14)	0.92 (0.11)	*	22.1
Education	0.25 (0.35)	0.25 (0.38)	0.34 (0.40)	0.43 (0.43)	0.49 (0.43)	0.58 (0.44)	0.71 (0.41)	*	39.4

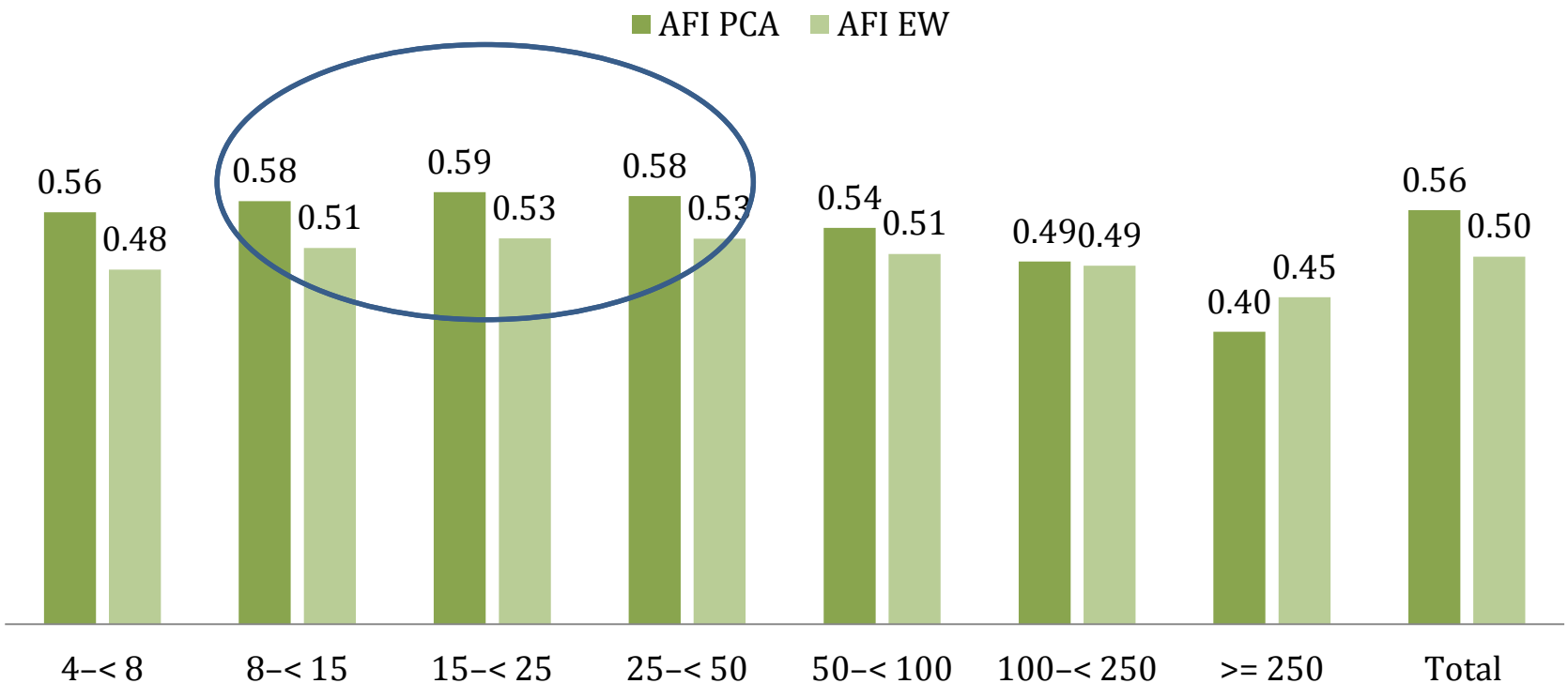
** Difference is significant.*

Lithuanian family farms agri-environmental performance indicators values by farming type in 2017

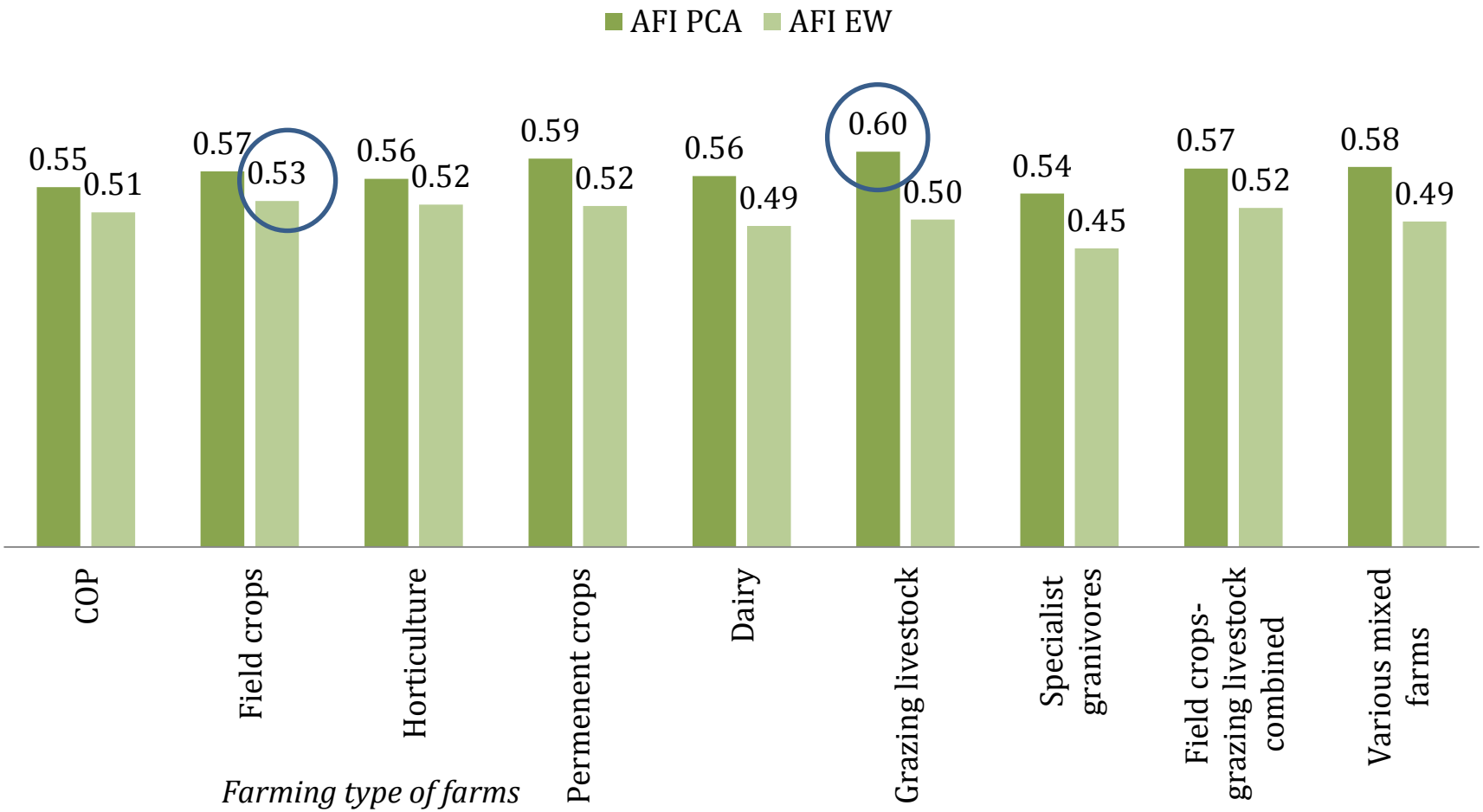
Indicators	COP	Field crops	Horticulture	Permanent crops	Dairy	Grazing livestock	Specialist granivores	Field crops-grazing livestock combined	Various mixed farms	Significance	CV
Use of fertilizers	0.67 (0.32)	0.83 (0.22)	0.71 (0.38)	0.81 (0.36)	0.92 (0.12)	0.94 (0.10)	0.86 (0.20)	0.91 (0.15)	0.93 (0.15)	*	11.6
Use of crop protection	0.72 (0.31)	0.85 (0.29)	0.73 (0.39)	0.79 (0.37)	0.94 (0.13)	0.95 (0.11)	0.90 (0.15)	0.93 (0.11)	0.95 (0.12)	*	10.9
GHG emissions	0.92 (0.14)	0.97 (0.08)	0.98 (0.04)	0.99 (0.01)	0.93 (0.11)	0.93 (0.08)	0.91 (0.17)	0.94 (0.11)	0.98 (0.03)	*	3.2
Energy intensity	0.61 (0.31)	0.71 (0.30)	0.81 (0.18)	0.70 (0.31)	0.70 (0.24)	0.63 (0.26)	0.86 (0.14)	0.59 (0.27)	0.67 (0.23)	*	12.8
Biodiversity	0.76 (0.22)	0.72 (0.27)	0.90 (0.24)	0.32 (0.40)	0.67 (0.32)	0.62 (0.33)	0.44 (0.43)	0.78 (0.26)	0.78 (0.27)	*	27.4
Meadows and pastures	0.03 (0.08)	0.07 (0.23)	0.00 (0.03)	0.04 (0.13)	0.20 (0.27)	0.20 (0.12)	0.18 (0.39)	0.16 (0.17)	0.12 (0.21)	*	70.2
Livestock density	0.97 (0.08)	0.93 (0.15)	0.86 (0.25)	1.00 (0.01)	0.46 (0.26)	0.49 (0.25)	0.08 (0.21)	0.73 (0.18)	0.64 (0.30)	*	44.1
Wooded area	0.12 (0.31)	0.12 (0.32)	0.09 (0.29)	0.04 (0.18)	0.11 (0.30)	0.03 (0.15)	0.10 (0.29)	0.13 (0.34)	0.07 (0.25)	*	40.1
Accessibility	0.04 (0.19)	0.05 (0.22)	0.01 (0.07)	0.06 (0.23)	0.03 (0.18)	0.10 (0.31)	0.00 (0.00)	0.10 (0.30)	0.04 (0.21)	*	73.1
Environment-friendly farming	0.10 (0.30)	0.09 (0.26)	0.10 (0.24)	0.35 (0.42)	0.08 (0.24)	0.07 (0.21)	0.01 (0.10)	0.11 (0.27)	0.14 (0.31)	*	80.9
Water consumption	0.74 (0.29)	0.65 (0.35)	0.70 (0.40)	0.75 (0.35)	0.56 (0.35)	0.56 (0.38)	0.85 (0.22)	0.59 (0.36)	0.39 (0.36)	*	21.1
Education	0.42 (0.42)	0.29 (0.41)	0.36 (0.36)	0.39 (0.46)	0.23 (0.35)	0.46 (0.41)	0.26 (0.35)	0.23 (0.39)	0.24 (0.35)	*	27.8

** Difference is significant.*

The AFI values by economic farm size class for Lithuanian family farms in 2017



The AFI values by type of farming for Lithuanian family farms in 2017



CONCLUSIONS

1. the research highlighted the approach to the evaluation of farm-scale agricultural environmental performance that aimed to draw attention on possibilities at the use of available and reliable FADN data. The developed AFI based on Lithuanian FADN primary data contributing to 12 indicators was validated on different farm groups.
2. The findings of AFI indicate good level of environmental performance of Lithuanian family farms as three-fourths of the sampled farms were defined by medium AFI level. Nevertheless, more than 10% of farms achieved low level of AFI and these farms need more stimulus for better environmental performance.
3. The obtained AFI results indicate further policy revisions in order to induce changes on the use of natural resources and on organization of spaces on farms as the values of indicators related to farms' accessibility, adoption of environment-friendly farming practices, wooded and meadows and pastures areas on farms were found the lowest for the whole Lithuanian farms sample.

CONCLUSIONS

4. The results of the AFI provide a new knowledge about farms environmental performance, disclose problems and facilitate comparison analysis among farm groups and can be the basis for political decisions that could contribute to the agricultural sector development in a sustainable way in Lithuania.

5. Do not reinvent the wheel–the index structure is flexible and can respond to diverse local policy needs. In case of the AFI use in practise, the weights to indicators could be assigned by experts. Furthermore, FADN could be a cost-effective option to meet the needs for policy reporting , therefore including some agricultural management-related indicators in FADN, such as nutrient balances, quantities of wastes, recycled wastes, use of renewable energy, share of alternative water source (on-farm ground water, on-farm surface water and etc.), number of cultural species on farms could be considered.

THANK YOU FOR YOUR ATTENTION!

Vida Dabkienė
Lithuanian institute of agrarian economics