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MEASURING THE ECONOMIC DIMENSION OF SUSTAINABLE AGRICULTURE: THE CONSTRUCTION AND ANALYSIS OF FARM LEVEL INDICATORS

Key words: sustainable agriculture, financial indicators, FADN, farm classification

ABSTRACT. The concept of sustainable agriculture is based on the paradigm of sustainable development. Sustainable agriculture refers to farm production systems and combines economic, social and environmental dimensions. Most often it covers issues related to environmental protection and improving the quality and standard of living of farmers. In conducting scientific research, the basic problems are measuring the degree of sustainability and classification of farms. The aim of the research was to develop an indicator measuring the economic dimension of sustainable agriculture and determine its size in various farm types. The assessment of individual groups of farms was based on an original set of indicators determining their economic situation. Consequently, the synthetic economic dimension indicator of sustainable agriculture (*ESD*) was used for farm evaluation. The conducted research showed that over 60% of groups of farms operating in 2010-2017 reached the target value of the indicator of the economic dimension of sustainable agriculture. Economic size and farm type were determinants of this situation. The results obtained indicate an increase in the economic dimension indicator of sustainable agriculture together with a higher class of economic size. Whereas the farms dealing with dairy were the type of farm with the highest values of the built indicator. Analysis of literature sources and the conducted research confirmed the complexity of the assessment of production systems and the impact of the choice of indicators on the degree of their sustainability.

INTRODUCTION

The concept of sustainable development tends to create behaviour limiting pressure on the natural environment caused by i.a. an increase in the world's population. The implementation of this idea in all sectors, including its transfer to the agricultural sector and agricultural economics clarified the term sustainable agriculture [Czyżewski, Staniszewski 2018]. Definitions of sustainable agriculture include issues related to the need of reconciling production objectives and objectives related to environmental protection and provide farmers with income improving their quality of life [Pretty 2007, Hansen 1996, Macrae et al. 1993, Krasowicz 2005, Guth, Smędzik-Ambroży 2017]. Dan Rigby and Daniel Caceres [1997] list the following long-term goals: (a) satisfying human food needs; (b) improving the quality of the environment; (c) making the rational use of non-renewable energy sources; (d) using resources supplying "green" energy on farms; (e)

maintaining agricultural profitability of agricultural activities; (f) improving the quality of life in rural areas, and thus the quality of life of society as a whole.

Sustainable agriculture encompasses the following three pillars: economic, environmental and social [Zegar 2007, Godfray 2015, Struik, Kuyper 2017, Lindblom et al. 2017, Czyżewski, Staniszewski 2018]. When studying literature dealing with issues of sustainable agriculture, there are many ways to measure it. Most often they rely on the calculation of indicators characterizing individual components of sustainable agriculture [Mahon et al. 2016, Gadanakis et al. 2015, Scherer et al. 2018, Latruffe et al. 2016]. Particular attention is paid to the aspect of the agricultural production impact on the environment and the search for indexes reflecting the level of pressure on natural resources. They relate to the use of artificial fertilizers, the use of water resources, crop diversity, biodiversity and changes in landform features. However, this is not the right approach since it overlooks social and economic aspects that should be included in the research process [German et al. 2017, Gómez-Limón, Sanchez-Fernandez 2010]. The measurement of balance itself can take place at many levels. These include global, regional, sectoral, individual (farms) and special (range determined by the researcher) scales [Kelly et al. 2018].

The aim of the research is to build a synthetic measure of the economic dimension of sustainable agriculture and determine its height in groups of highly specialized farms in crop and livestock production, as well as mixed farms. Groups of Polish farms conducting production in 2012-2017 were selected for the study.

MATERIAL AND RESEARCH METHODS

The source of data was information falling within the field of observation of the Polish Farm Accountancy Data Network (FADN) defined as highly specialized in: pig production; beef production; dairy; production of cereals, oilseeds and protein crops and mixed farms. The research was carried out for 24 groups of farms (annually) operating in 2010-2017.

Due to the availability of data and conditions for the protection of accounting data from a farm, aggregated data was used. This data was made available by the Institute of Agricultural and Food Economics – the National Research Institute and are arithmetic averages from a given group of an analysed set of farms.

The assessment of the economic dimension of sustainable agriculture was carried out based on 20 indicators, the calculation method of which is presented in Table 1. It is a set of indicators developed on the basis of analysis of literature sources, which takes the correlation between indicators into account in order to eliminate factors with low diagnostic quality.

The next step of the research was indicator normalization. This action was intended to calculate a synthetic indicator of the economic dimension of sustainable agriculture (*ESD*). This process took place in three stages [Mili, Martínez-Vega 2019, Martínez-Vega et al. 2016]:

Table 1. Indicators used to measure the economic dimension of sustainable agriculture

Number of ratio	Group of ratios/Ratio	Ratio calculation in FADN variables
Profitability		
ER1	Operational costs per output	Total Input/Total output
ER2	Farm net value added per LU	Farm net value added/Total livestock units
ER2a	Farm net value added per ha Total Utilised Agricultural Area (only crop farms)	Farm net value added/Total Utilised Agricultural Area
ER3	Farm net value added per capital	Farm net value added/Total assets
ER4	Family farm income per FWU	Family Farm Income/FWU
ER5	Net profitability	Farm Net Income/cost for unpaid work and capital
ER6	Return of assets	Farm Net Income – cost for unpaid work/ Total assets
ER7	Return of sale	Farm Net Income – cost for unpaid work/ Total crops, livestock and other outputs
ER8	Return of equity	Farm Net Income – cost for unpaid work/ Net worth
ER9	Operating profit margin ratio	Farm Net Income – cost for unpaid work/ Total output + Total subsidies – excluding investments
Autonomy/Transmissibility		
ER10	Current ratio	Circulating capital/Short-term loans
ER11	Cash flow ratio	Cash Flow (1)/Total output
ER12	Dynamic gearing ratio	Cash Flow (1)/Total liabilities
ER13	Share of subsidy in family farm income [%]	Total subsidies – excluding investments/ Farm Net Income
ER14	Total external factors in total costs [%]	Total external factors/Total Input
Financial efficiency and Stability		
ER15	Assets turnover ratio	Total output + (Total subsidies –excluding investments)/Total assets
ER16	Operating expense ratio	Total Input – Depreciation/Total output
ER17	Depreciation expense ratio	Depreciation/Total output
ER18	Fixed assets-total assets ratio	Total fixed assets/Total assets
ER19	Equity-fixed assets ratio	Net worth/Total fixed assets
ER20	Debt-equity ratio	Total liabilities/Net worth

Source: own construction based on [Zorn et al. 2019, Latruffe et al. 2016, Gómez-Limón, Sanchez-Fernandez 2010]

1. Standardization of indicators (*NV*) – dividing the values of calculated indicators (*ER*) by the target value of the indicator (*TER*). Since some of the indicators are destimulants (a low value of a given indicator is desired), they have been transformed (in terms of quotient) into stimulants. The target value was set at the 85th percentile of the studied indicator in individual groups of farms (types, classes of economic size). Its level was taken from research on sustainable agriculture conducted by Samir Mili and Javier Martínez-Vega [2019]. The authors emphasize that it is difficult to find a precisely defined level of target value in the literature. A guideline for establishing its level may be adopted by the OECD [2019]. The value of indicators measuring sustainable development of OECD members is set at the 90 percentile (indicators for which there are no guidelines contained in international agreements).

$$NV_i = \frac{ER_i}{TER_i}$$

2. The second stage consisted of calculating the indicator for individual farm groups and individual years of analysis according to the formula:

$$ESD_i = (\text{average } (ER1_i, \ldots., ER20_i) - 1) \times 100$$

3. The last stage was the normalization of obtained *ESD* (X_i) indicators based on the average for the studied groups of farms in a given year ($\bar{X}$) and standard deviation ($\hat{\sigma}_x$). Thanks to this, indexes (*NESD*) were obtained showing how far the value is from the average:

$$NESD_i = \frac{X_i - \bar{X}}{\hat{\sigma}_x}$$

The effect of the method used was to obtain dimensionless quantities that enable a comparison of surveyed farm groups. The results obtained were grouped depending on the type of farm, economic size class and *NESD* index. Data was visualized in tabular forms, tables with a colour effect and a chart.

RESEARCH RESULTS

Table 2 presents deviations from the average values of the indicator of the economic dimension of sustainable agriculture (*NESD*) in groups of farms separated by type and class of economic size. Negative values mean that a given group is characterized by a lack of sustainable agriculture, because one of its (Economic) areas has not been ensured. The analysis of results showed that, in 2010-2017, the largest percentage of farms not achieving the average level of the economic dimension of sustainable agriculture (negative values) indicator occurred in groups of pig farms (50%), beef (44%) and mixed farms (40%). The situation of dairy and cereal, oilseed and protein crop (COP) farms, in which the share of groups with a negative *NESD* index among all groups of a given type did

Table 2. *NESD* index values in farm groups

Type of farms	Farms represented 2010-2017 (min-max)	ES6*	2010	2011	2012	2013	2014	2015	2016	2017
Pig farms	16-51	VS	-2.1	-1.9	-2.0	-0.7	-2.7	-1.9	-1.8	-2.2
	155-251	S	-1.2	-0.8	-0.4	0.1	-1.0	-0.8	-1.0	-1.0
	205-273	MS	-0.6	-0.1	0.1	0.3	-0.2	0.1	-0.1	-0.1
	224-306	ML	0.1	0.5	0.6	0.4	0.3	0.4	0.6	0.4
	182-231	L	1.1	1.0	0.9	0.6	0.8	0.9	1.0	1.1
Beef farms	56-111	VS	-1.8	-2.4	-2.3	-4.0	0.7	-3.3	-2.7	-2.0
	180-605	S	-0.9	-1.2	-1.0	-1.6	0.7	-1.2	-0.8	-0.8
	70-262	MS	0.1	0.6	0.2	0.1	2.3	0.1	0.5	0.1
	22-83	ML	1.4	0.6	1.0	0.8	1.3	1.0	1.0	0.5
Dairy farms	236-419	S	-1.0	-1.2	-1.9	0.3	-0.1	0.2	0.2	0.1
	615-829	MS	-0.2	-0.1	-0.1	0.3	0.1	0.4	0.4	0.2
	366-695	ML	0.5	0.6	0.6	0.4	0.3	0.5	0.7	0.4
	75-185	L	1.0	1.0	1.0	0.5	0.5	0.7	1.0	0.6
COP farms	97-186	VS	1.1	1.0	0.8	0.2	-0.2	0.2	-0.3	1.4
	413-766	S	-0.3	-0.3	-0.2	0.3	-0.2	0.3	0.1	-0.3
	282-481	MS	0.1	0.2	0.2	0.4	0.1	0.5	0.4	-0.1
	150-327	ML	0.3	0.5	0.6	0.4	0.2	0.5	0.5	0.3
	61-156	L	1.4	0.8	0.8	0.5	0.4	0.6	0.9	0.4
Mixed farms	244-558	VS	1.3	1.2	1.2	-0.1	-1.6	-0.7	-1.7	2.0
	1,309-1,751	S	-0.9	-1.1	-0.9	0.1	-0.8	-0.1	-0.6	-1.7
	915-1,248	MS	-0.4	-0.3	-0.2	0.3	-0.1	0.3	0.2	-0.7
	405-696	ML	0.1	0.3	0.3	0.4	0.2	0.5	0.6	0.1
	85-213	L	0.8	0.8	0.7	0.5	0.6	0.7	1.0	0.5

– negative values of *NESD* index

* VS – very small farms (2,000 ≤ € < 8,000), S – small farms (8,000 ≤ € < 25,000), MS – medium-small farms (25,000 ≤ € < 50,000), ML – medium-large farms (50,000 ≤ € < 100,000), L – large farms (100,000 ≤ € < 500,000)

Source: own calculation

not exceed 25%, can be assessed positively. Another distinguishing element of the milk production group is that, as of 2013, only positive deviations from average indicators of the economic dimension of sustainable agriculture were recorded. This situation did not occur in other types of farms.

Adopting economic size class as criterion for analysis allows for the statement that, in 2010-2017, among the very small and small farms, the lowest values of the economic dimension indicator of sustainable agriculture dominated (Table 2). The consequence of this was the largest number of negative *NESD* index values in these groups. This particularly concerned pig and beef farms, in which almost all groups of very small and small farms were characterized by negative index values. The regularity that results from the results of the performed tests is the relationship between the *NESD* index value and the economic size class. In the analysed groups of farms, with the higher economic size class, the number of groups characterized by a higher than average value of the index of the economic dimension of sustainable agriculture also increased. This is confirmed by the fact that in the medium-large and large classes only positive *NESD* index values occurred.

The analysis of the size of deviations from average values of the indicator of the economic dimension of sustainable agriculture showed that over 60% of groups of very small and small farms had negative deviations (Table 3). In addition, half of the very small farms achieved deviations exceeding a value of -1.5, and the group of pig and beef farms accounted for about 80%.

Table 3. The structure of the farms' group by size of deviation from the average of the economic dimension of sustainable agriculture

NESD index	Economic size classes*					All farms
	VS	S	MS	ML	L	
	%					
Under -1.50	50	8	0	0	0	10
From -1.50 to -1.00	0	20	0	0	0	4
From -0.99 to -0.50	6	27	4	0	0	8
From -0.49 to 0.00	9	20	30	0	0	13
From 0.01 to 0.50	6	22	60	52	9	33
From 0.51 to 1.00	6	3	3	40	66	22
From 1.01 to 1.50	20	0	0	8	25	9
Above 1.50	3	0	3	0	0	1

* see Table 1

Source: own calculation

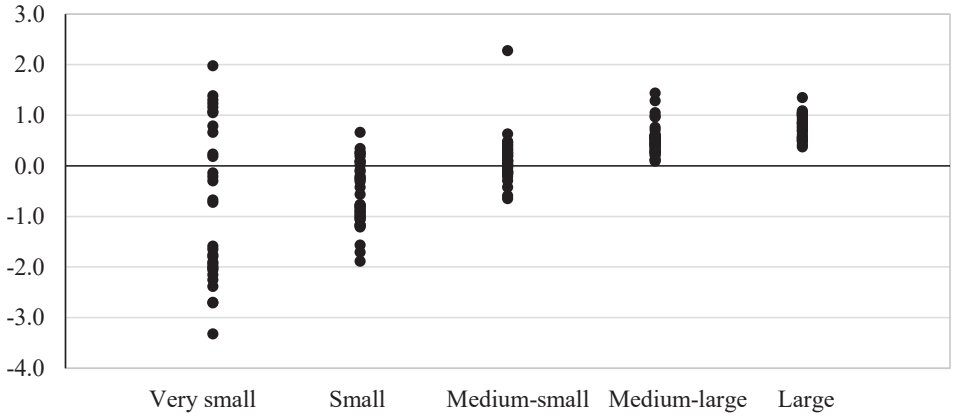

Figure 1. *NESD* index values in farm groups by economic farm size class
Source: own calculation

Positive deviations of the index occurred in all classes of farms classified by economic size. Starting from medium-small farms, the percentage increased in the next (higher) class and in medium-big and big farms it was 100%. Taking the entire population into account, 65% of all groups of farms had an indicator of the economic dimension of sustainable agriculture higher than its average in a given group. The most common positive deviations were on dairy and specialist cereal, oilseed and protein crop farms.

Figure 1 reflects deviations of the economic dimension indicator of sustainable agriculture in groups of farms distinguished by economic size class conducting production in 2010-2017. Two dependencies can be observed. Firstly, the *NESD* index range decreased with the next economic class size. In the group of very small farms, it amounted to six points, while in the group of large farms its size did not exceed one point. Secondly, there is a relation between the size of the economy class and the number of farm groups with a positive deviation from the average value of the index of the economic dimension of sustainable agriculture. This is confirmed by the fact that the group of large farms only deals with positive values of the *NESD* index.

CONCLUSIONS

An important change in the use of the concept of sustainable development in agriculture is the increasing importance of social and economic dimensions. Scientists are constantly looking for the best set of indicators to give a real picture of the activity and sustainability of farms. One of the three areas of sustainable agriculture is the economic dimension. The value of the indicator depends on parameters that will be used to measure it.

An attempt to assess production systems is associated with a selection of appropriate indicators classifying agricultural farms by degree of sustainability. The article proposes

an original set of indicators characterizing the economic dimension of sustainable agriculture. The conducted research shows that over 60% of the analysed groups of farms have achieved the set target value of the indicator of the economic dimension of sustainable agriculture. It was noticed that the basic impact on the inclusion of a farm in a given set came from: the economic size class and its type. Generalization of results gives grounds to state that:

– the economic dimension indicator of sustainable agriculture increased with the higher class of economic size.
– farms highly specialized in dairy were the type of farm characterized by the highest values of the analysed indicator of sustainable agriculture.

The studies performed only concern one of the elements of sustainable agriculture and on their basis it is not possible to indicate whether the farm meets all the requirements of sustainable agriculture. When studying the literature on the use of indicators in the study of sustainable agriculture, a rather controversial approach to the construction of a synthetic indicator was observed. It consists of the fact that such an indicator can define the production system as sustainable while not balancing one of the dimensions (e.g. a negative result for the economic dimension). Therefore, when conducting this type of research, extreme caution should be exercised, and the results obtained should be analysed in detail.

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POMIAR WYMIARU EKONOMICZNEGO ROLNICTWA ZRÓWNOWAŻONEGO: BUDOWA I ANALIZA WSKAŹNIKÓW NA POZIOMIE GOSPODARSTWA

Słowa kluczowe: rolnictwo zrównoważone, wskaźniki finansowe, FADN, klasyfikacja gospodarstw

ABSTRAKT

Koncepcja rolnictwa zrównoważonego oparta jest na paradygmacie zrównoważonego rozwoju. Odnosi się ona do systemów produkcji gospodarstw rolnych i łączy wymiary: ekonomiczny, społeczny i środowiskowy. Najczęściej obejmuje zagadnienia związane z zapewnieniem bezpieczeństwa żywnościowego, ochroną środowiska naturalnego oraz poprawą jakości życia rolników. W prowadzeniu badań naukowych podstawowymi problemami są pomiar stopnia zrównoważenia oraz klasyfikacja gospodarstw. Celem wykonanych badań było opracowanie wskaźnika mierzącego wymiar ekonomiczny rolnictwa zrównoważonego oraz określenie jego wielkości w różnych typach gospodarstw. Ocenę wyodrębnionych grup gospodarstw oparto na autorskim zestawie wskaźników określających ich sytuację ekonomiczną. Dzięki zastosowanej metodzie dokonano obliczenia wskaźnika wymiaru ekonomicznego rolnictwa zrównoważonego (*ESD*). Wyniki badań wskazują, że ponad 60% grup gospodarstw prowadzących działalność w latach 2010-2017, osiągnęło wartość docelową wskaźnika wymiaru ekonomicznego. Determinantami tej sytuacji były klasa wielkości ekonomicznej oraz typ gospodarstwa. Uzyskane rezultaty wskazują na wzrost wskaźnika wymiaru ekonomicznego rolnictwa zrównoważonego wraz z wyższą klasą wielkości ekonomicznej. Natomiast typem gospodarstwa o najwyższych wartościach zbudowanego wskaźnika były gospodarstwa zajmujące się produkcją mleka.

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