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Estimation of the European Development Framework to Measure Bulgarian Field Crops Farm Sustainability by Economic Size Classes

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Abstract: Creating the European development framework to measure farm sustainability involves estimation of average European Union rates on the farm level, which excludes different farms' specializations and economic size classes.
This paper aims to find out the sustainability benchmark and the average levels of each economic size class of the EU's field crops farm sustainability of all economic size classes, which requires some basic indicators covering the main sustainability dimensions – economic, social, and ecological.
The applied methods for the construction of the Composite Sustainability Indexes combine two different approaches. The Relative Comparative Assessment is a tool normalizing the used variables to calculate farm sustainability scores for the different pillar evaluations, as well as the compound index, while the "Benefit-of-the-Doubt" modification of Data Envelopment Analysis estimates the sustainable development policy efficiency. Results determine exactly how the area payments push large-scale field crop farms' sustainability up by strongly supporting a larger production scale, at a cost to the smallest entities.

Keywords: field crops; agricultural holdings; sustainability assessment; economic size classes; common agricultural policy; policy efficiency

INTRODUCTION

The main role of the Common Agricultural Policy (CAP) is to support farm sustainability and, more specifically, the income of people who are engaged in food production, especially the supplements and raw materials production (European Commission, 2023).

However, by applying area payments, the European Commission may delegate the cash flows in favor of the larger landlords, which might be crucial to transform the economic size and furthermore the agricultural sustainability of the producers. Raising this topic is the main objective of this paper, but also to find out how the agricultural holdings are affected and how the connection between farm economic size and sustainability is developed within the three main sustainability pillars.

CAP, as an important object of the academic community, is now based on values (European Parliament, 2013), highlighted at the Conference in Rio de Janeiro – a monitoring system on the sustainability of farming entities to be established (United Nations, 1992). However, a collection of farm performance indicators requires serious efforts to be made in order for data homogeneity to be available and for the construction of a long-term observation to be possible. Quantitative data scarcity is proposed by the Organization for Economic Co-operation and Development. OECD provides a method to address that issue (like in the current case) where proxy indicators might be used (Nardo et al., 2008).

In 2008 the Organization of Economic Cooperation and Development issued the Handbook on Constructing Composite Indicators (or indices), where the "Benefit of Doubt" approach (modification of Data Envelopment Analysis) was presented as an instrument for benchmarking countries` performance (Nardo et al., 2008) especially appropriate for the needs of measuring sustainable development (Cherchye and Kuosmanen, 2006). The authors proposed an approval of the method usage that estimates the achieved technological production level in a competitive economic environment that is applicable as a policy application efficiency, concerning all other conditions being equal.

Such examples are soil quality or climate and weather impact, which form the uncontrollable (natural) factors of uncertainty. Their main characteristic is a difficult predictability, and according to the Bulgarian Center for Agricultural Sciences, they take about 55 – 60% of the total factors of influence on the agricultural production. (MAF, 2004). Unfortunately, Data Envelopment Analysis cannot keep that into consideration and is ignored in the modeling, too. This instrument has already been used as a composite index assessment instrument in the context of policy effectiveness assessment (Cherchye et al., 2007).

CAP implementation as a governance initiative needs to be transparent, and furthermore, the political decisions need to be taken democratically (Sarov et al., 2023) in order for each side of the target groups (decision-making units or DMUs) to be satisfied at a certain level. Nikolov et al. finally concluded that large field crop farms seriously count on CAP support to strengthen their socio-economic objectives as main farm sustainability goals (Nikolov et al., 2024), which also concerns their ecological aspects to be supported. This paper aims to give a cleaner view of that topic and, furthermore, to compare different farms` production scales and economic size performances based on available basic indicators extracted from a single database over a long-term time period that covers two consecutive mid-term policy schemes. The first policy application period was from 2007 to 2013, but the same schemes were also applied in 2014, while the CAP period to 2020 was elongated to 2022.

Another aim of the survey is to find out the most sustainable farm specialization and/or economic size class and to compare the other farm structures according to a level of "unsustainability" in a brand new benchmarking system. It requires all types of farming to be inspected and also totally new estimations to be made in the future author's labor. A comparative assessment within the whole European Union needs to be done concerning all available types of farming: wine and milk production, horticulture and permanent crops (orchards), animal husbandry – granivores and herbivores, and mixed farming.

Such information is provided by the European Commission's Farm Accountancy Data Network, where data is available on 8 and even 14 types of farm specializations, and also 6 economic size classes, where, first of all, the most widely important for Bulgarian agriculture will be prioritized.

This paper requires a basic framework assessment of field crop farming to be found, which is provided by the data on the mean (average) member state farm holding data forming the EU farm average level as a common denominator.

MATERIALS AND METHODS

A holistic approach was applied in this study, which combines two different assessment methods that modify some Farm Accountancy Data Network variables used as a production technology optimization, in order to facilitate a comparison between the member states, which will be further presented. Their combination as a compound index gives the final score of each independent economic size class for establishing a framework for European farm development. Afterward, each single MS (as well as different economic size classes) may be exposed as a single decision-making unit performing within it.

In his previous labor, the author had established a sustainability measuring system using five basic indicators covering each of the three main sustainability aspects – economic, ecologi-

cal, and social. That setting was applied on two different and approved methods, both combining 15 different variables in total (Krustev, 2023). This paper presents the first of a series dedicated to a specific farm specialization after obtaining and unraveling the sustainability level used here as a common denominator and benchmark.

Assuming a perception of the area payment, one of the most supported farm specializations is expected to be the field crop farm. This statement should be confirmed in the author's further observations, where all the farm specializations should be inspected in terms of farm sustainability and the CAP implementation efficiency.

Building a Composite Sustainability Index includes a combination of two different methods to construct an overall complex sustainability estimation. Each of them aggregates 15 variables, which are completely different in the economic pillar, but some are based on the same logic in the other pillars. However, in the Relative Comparative Assessment (RCA), a denominator is used in order to compare different production scales, e.g., per annual working unit or per unit area. On the other hand, the Benefit of the Doubt modification of the Data Envelopment Analysis (DEA-BoD) involves the indicators to be used in a way that differentiates the diversity of farm production scales (also return to scale may be found as increasing or decreasing). Therefore, between those indicators and assessment technologies, there is a huge difference.

The modeling tool calculates the sustainability scores of MS's policy implementation by measuring the decision-making units` (DMUs) technical efficiency. This aim was reached by using Data Envelopment Analysis through its Benefit of Doubt setting – respectively, five indicators for each sustainability pillar and a 15-indicator model that combines all of the basic variables. Most of the indicators point out the production scale of the production units, which involves their natural values to be used.

The second one – the Relative Comparative Assessment estimates farm sustainability using complex indicators, where the indicators are compared to related measures. Each pillar estimation aggregates five normalized indicators. The final index averages the pillars` results, giving a compound sustainability measurement.

The used data set is taken from the Farm Accountancy Data Network (2007 – 2022). The Relative Comparative Assessment takes 37 simple indicators to form all the complex sustainability variables:

Relative Comparative Assessment Indicators

Economic variables:

1. Labour Productivity = Total Output/Total Labour Input (€/AWU);

2. Diversification Level* = 1 - {[(Max Output (FADN~SE140÷SE245) – Average Output) + (Average Output – Min Output)]/Total Output};

3. Profitability = Farm Net Income/(Total Farm Inputs – Own Farm Production Factors);

4. Capital Productivity = Total Output/Average Farm Capital;

5. Economic Resilience (Bachev et al., 2017) = (Total Output – Total Subsidies excluding on Investments – Subsidies on Investments)/(Other Direct Inputs + Depreciations + Total External Factors);

* The Diversification Level is expressed by the reciprocal value of a Specialization Level.

The economic indicators (2 – 5) are expressed by coefficients that do not have a specific measuring unit, as well as 10, 11, and 15.

Social variables:

6. Family Farm Income per Family Working Unit (€/FWU);

7. Internal Consumption per Family Member = Farmhouse Consumption/Unpaid Labour Input (€/FWU);

8. Farm Salaries = Wages Paid/Paid Labour Input (€/AWU);

9. Farm Own Factors of Production = Farm use/Total Utilized Agricultural Area (€/ha);

10. Share of Own Land = 1 - Rented Utilized Agricultural Area/Total Agricultural Area;

Ecological variables:

11. Share of agro-ecological payments of the total plant production subsidies;

12. Fertilizer Usage per Unit Area = Fertilizers/Input Intensified Area(€/ha)**;

13. Pesticide Usage per Unit Area = Crop Protection/Input Intensified Area (€/ha)**;

14. Energy Intensity = Energy/Total Utilized Agricultural Area (€/ha) ***;

15. Protein Crops Share in the Crop Rotation = Protein crops/Cereals + Energy crops + Potatoes + Sugar beet + Oil seed crops + Industrial crops.

** Input Intensified Area = Arable Land + Permanent crops

*** Indicator's type is "less is better", also applicable to **

Data Envelopment Analysis Indicators

The formation of the DEA-BoD index involves only 19 simple indicators (only 4 of the variables are complex: 2 social and 2 ecological):

Economic variables:

1. Total labor input (AWU);
2. Total utilized agricultural area (ha);
3. Intensification level: total crop output (€/ha);
4. Total farm assets (€/farm);
5. Total farm output (€/farm).

Social variables:

6. Family farm income/Family working unit (€/FWU);
7. Wages paid/Paid labor input (€/AWU);
8. Own production factors (€/farm);
9. Gross farm income (€/farm);
10. Rural community support = Contract work (€/farm) + Rent paid (€/farm).

Ecological variables:

11. Fertilizers (€/farm);
12. Crop protection (€/farm);
13. Energy (€/farm);
14. Protein crops (as a share of the crop rotation) = Output of protein crops/Total output of crops & crop production;
15. Ecological focus of the holding = Environmental subsidies/Total subsidies on crops.

Assessment methods:

1. Relative Comparative Assessment

In order to focus on the majority of results and to put the attention on the center of the scale, to normalize the data, and to form a score, the following ranking formula was applied to design the values to fit between 0 and 1:

$$\textbf{Indicator Score} = \frac{\textbf{FADN Value} * (0.5 + 0.5\,CV^2)}{\textbf{St Dev + AVG}}$$

Where:

Coefficient of Variation (CV) = Standard Deviation (St Dev)/Average (AVG)

The formula is applied to each of the 15 complex indicators used, for each average holding of each member state, including all the field crops economic size classes during the whole inspected period, where data is available.

In order for all types of farming to be included (FADN provides 8 types of farming) and to be compared, as a form of future development of the current topic, standard deviation and average values are calculated for the whole sample of all 8 types of farming.

The applied method concentrates the normalized data around the middle of the scale, and in some exceptional cases, a normalized value above 1 can be obtained, which is equated to 1, and when there are negative values, they are equated to 0. So, as a consequence, to remove the spikes, the following restrictions on values needed to be applied:

i. value < 0 = 0;

ii. value > 1 = 1.

EU farm average values are taken from the sample of the average (national) EU member states, where each MS is represented by 1 synthetic production unit, and all types of farming were included.

2. Data Envelopment Analysis – Benefit of the Doubt modification

The Data Envelopment Analysis (DEA) creates a virtual producer on the best production function of the sample (2007 – 2022). Sometimes the best production function might not be found in the sample, but may use different patterns of several peers. Otherwise, the possibility of sev-

eral units performing the best score is also available (Berg, 2010).

To compare the non-best decision-making units` performance, DEA measures the distance of each one to the greatest (or virtual) performer. The calculation measures 2686 production functions in total, combining all economic size classes (6) of the EU's field crop farms and the average farms of all EU member states. Each agricultural holding is used as a unique production function every individual year to receive its specified index. However, there is a lack of data for some MS, but all available data were taken into account in the calculations for this manuscript (Table 2). Each single score received by the program is expressed as a coefficient, which measures the distance to the best virtual producer as a value from 0 to 1.

Aiming for the proper use of this instrument to be applied for a combination of 15 variables, the "Benefit-of-the-doubt" modification is set. This model was approved as a tool for policy effectiveness assessment by Cherchye et al. in 2007, where the variables used in the sustainability scores` calculations are used as outputs of the DMUs` activities, while the production system input is ignored (Cherchye et al., 2007). It is an object of the optimization.

In particular, the five relative indicators were used as outputs for each pillar estimation. The sustainability assessment is made by an input-oriented model applying constant returns to scale (CRS) DEA model. The sustainability evaluations are received by technical efficiency results computed for each economic size class (ESC) of all member states` field crop farms. The peculiarity of the DEA composite indicator is specific, while adding more outputs (or inputs), and the efficiency computation becomes more complex. (Charnes et al., 1978). In such an occasion, the 15-indicator DEA sustainability efficiency scores are received in greater values compared to any of the pillar assessment scores.

3. Composite Sustainability Method

It contributes to broadening the scope of the overall sustainability assessment, being indicative of both the efficiency of the production activities of the farms and the effective use of the implemented policies in terms of sustainability.

The Composite Sustainability Indexes are formulated as an average of both independently previously calculated indices, as follows:

$$\textbf{Composite Index} = \frac{\textbf{DEA BoD Index} + \textbf{RCA Index}}{\textbf{2}}$$

It is calculated for each of the three pillars of sustainability as well as the overall sustainability indexation.

Main characteristics of the different farm economic size classes, as production factors or inputs and production results or output, are presented in Table 1.

Table 1. General characteristics of the average field crop farm size classes

Economic Size Class	Standard Output Range (€)	Total Utilized Agricultural Area (ha/farm)	Total output (€/farm)	Total output/ Total input (ratio)	Average Farm Class Economic size (€/farm)	Total labor input (AWU/farm)
1	2 000 ÷ < 8 000	9.7	8 351	1.14	6 000	0.99
2	8 000 ÷ < 25 000	22.5	23 335	1.10	16 000	1.08
3	25 000 ÷ < 50 000	48.2	50 360	1.08	37 000	1.38
4	50 000 ÷ < 100 000	86.2	94 356	1.09	72 000	1.72
5	100 000 ÷ < 500 000	217.8	254 475	1.09	207 000	3.26
6	≥500 000	922.3	1 265 594	1.07	980 000	14.01

Source: FADN.

Why are small farmers included and important? Besides, the real income generated by the first ESC seems to be very low and not sufficient even for a single person's expenditures; the smallest farmers are not fully engaged in the agricultural processes. It might be said that they are hobby farmers, and another job is expected to fill in a family budget. The reason their total farm output is a bit outside of the ESC range is that the standard output values are estimated for a 5-year period that covers previous production prices on an average basis.

Another specific feature of the smallest farm formations is their highest coefficient of output to inputs among the other field crops ESCs, which makes them quite profitable, as is even more sharply observed in the calculations of RCA's indicator number 3 of this paper, or more than twice.

Table 2. Member states' participation in the formation of each farm economic size class formation

MS	ESC 1	ESC 2	ESC 3	ESC 4	ESC 5	ESC 6
Bulgaria	☑	☑	☑	☑	☑	☑
Slovenia	☑	☑	☑	☑	☑	
Croatia	☑	☑	☑	☑	☑	
Hungary	☑	☑	☑	☑	☑	☑
Poland	☑	☑	☑	☑	☑	☑
Ireland				☑		
Romania	☑	☑	☑	☑	☑	☑
Portugal	☑	☑	☑	☑	☑	
Latvia	☑	☑	☑	☑	☑	☑
Luxemburg						
Spain	☑	☑	☑	☑	☑	☑
Greece	☑	☑	☑	☑	☑	
Cyprus	☑	☑	☑	☑	☑	
Lithuania	☑	☑	☑	☑	☑	☑
Belgium				☑	☑	☑
Malta	☑	☑	☑			
Italy	☑	☑	☑	☑	☑	☑
France		☑	☑	☑	☑	☑
Estonia	☑	☑	☑	☑	☑	☑
Czech Republic		☑	☑	☑	☑	☑
Germany				☑	☑	☑
Austria		☑	☑	☑	☑	
Finland		☑	☑	☑	☑	
Netherlands				☑	☑	☑
Denmark		☑	☑	☑	☑	☑
Slovakia		☑	☑	Q	☑	☑
Sweden		☑	☑	☑	☑	☑
United Kingdom			☑	☑	☑	☑

Source: FADN.

Those facts put the representatives of field crops ESC 1 in a position to be independent outside of CAP supporting schemes, give them the opportunity to cultivate special (even low productive) varieties and to organize unique processing and supply chains, to increase their production's value added, to find a special market niche, and to satisfy a highly solvent clientele.

To complete the engagement of such a specific type of farmers, it should be mentioned that they manage mostly their own land – about 2/3 of the total utilized area is their own property. The meaning of RCA's indicator number 10 is that the attitude towards something one owns (e.g. a child) is more different.

And finally, the diversity of small farmers keeps the rural areas alive by engaging people close to the land, producing their own food, and maintaining people's density in terms of AWU per unit area. These reasons might outline the small farmers as the last free people that will survive on the planet.

RESULTS AND DISCUSSION

Relative Comparative Assessment

Economic Farm Sustainability

Farm economic sustainability framework reveals the power of scale efficiency, which is strongly supported by CAP's area payments policy (Fig. 1).

However, at the beginning of the first program period (2008), the highest economic size class was performing lower than the other two higher agricultural formations (ESC 4 and ESC 5) and closer to the smaller farm classes, but afterward, the two largest ones are performing in a parallel direction.

It is easy to see in Figure 1 how the economic sustainability of ESC 4 is correlating to the EU farm average: a little bit higher during the first semi-period and lower during the second one, but until 2021, when it started strengthening.

In 2009, all the inspected farm classes experienced a drop in their economic activities, which

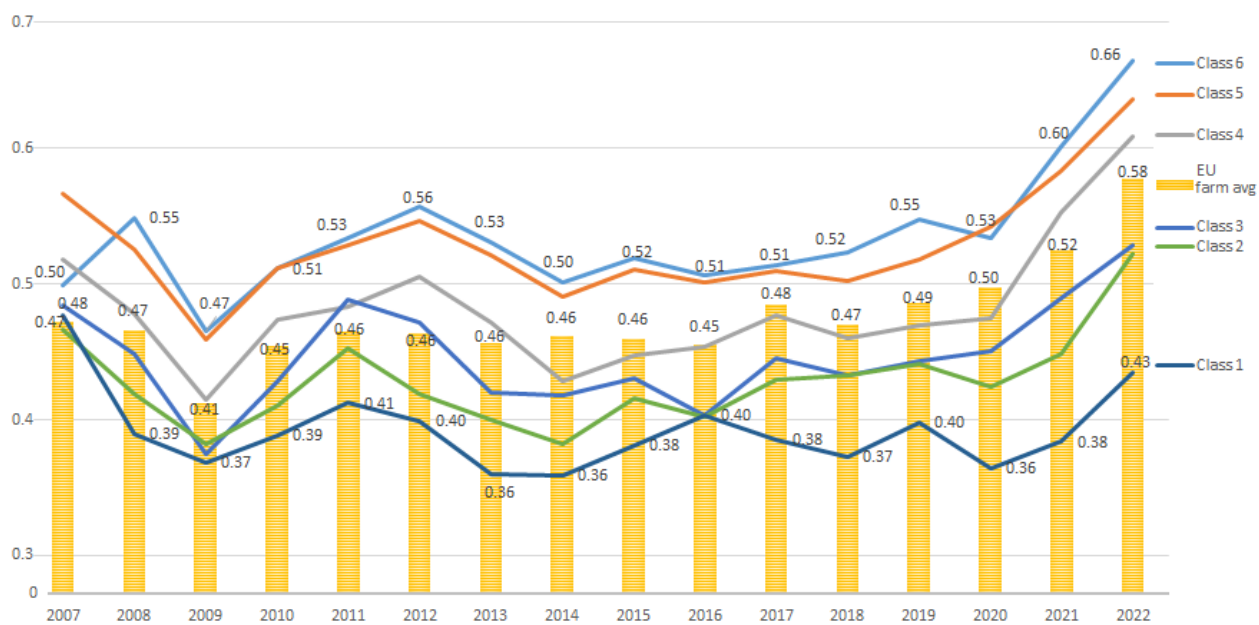


Fig. 1. European Development Framework to Measure Farm Sustainability estimated by the Relative Comparative Assessment Method

Source: Own Calculations Based on FADN.

was followed by an increase in 2011 – 2012, where the peaks of the first program period are observed.

Around the switch of CAP schemes (2013 – 2014), another depression in farm performance appears. It is even worse than the previous one concerning the two smallest ESC, where the poorest results might be seen.

After 2020, the EU farm average became as high as ever before in the observed time period. This might be due to minimizing the weight of small-scale farms and concentrating the land resources in the management of larger farm structures. In 2022, the ongoing peaks of the second program period were also the highest economic performance values of the RCA part of the current survey. This success is at a cost of reducing ecological values (Fig. 3), which outlines the main contradiction in the sustainability conception.

All the farm classes break their previous scores except the smallest ESC, whose beginning point used to be higher than the EU benchmark, but not for long, as it remains at a lower level.

Social Farm Sustainability

The selected main social indicators form an index that summarizes the lower value added of the land use of field crop farm holdings (Fig. 2), which is lower in comparison to the more intensive EU farm average farm area.

Farm revenue and the social benefits of the expressed values are also inflation-related. The economic results of a farm should also cover both social and ecological challenges and achievements. The trend of socially related activities is reflected in the burden on depressed cost budgets of entrepreneurs (2008 – 2010 and 2013 – 2016). This concerns the peaks of social indexation when it comes to the improvement of the values in 2011 – 2013 and after 2020, which unfortunately does not affect the first ESC, which stays at a very low level at the end of the current monitoring period. At the same time, the fourth ESC almost catches up to the ESC 5 level while the same is performed by the ESC 2 according to ESC 3. The leading position of the largest farms is settled by default, where the highest level of labor and capital productivity is also positioned.

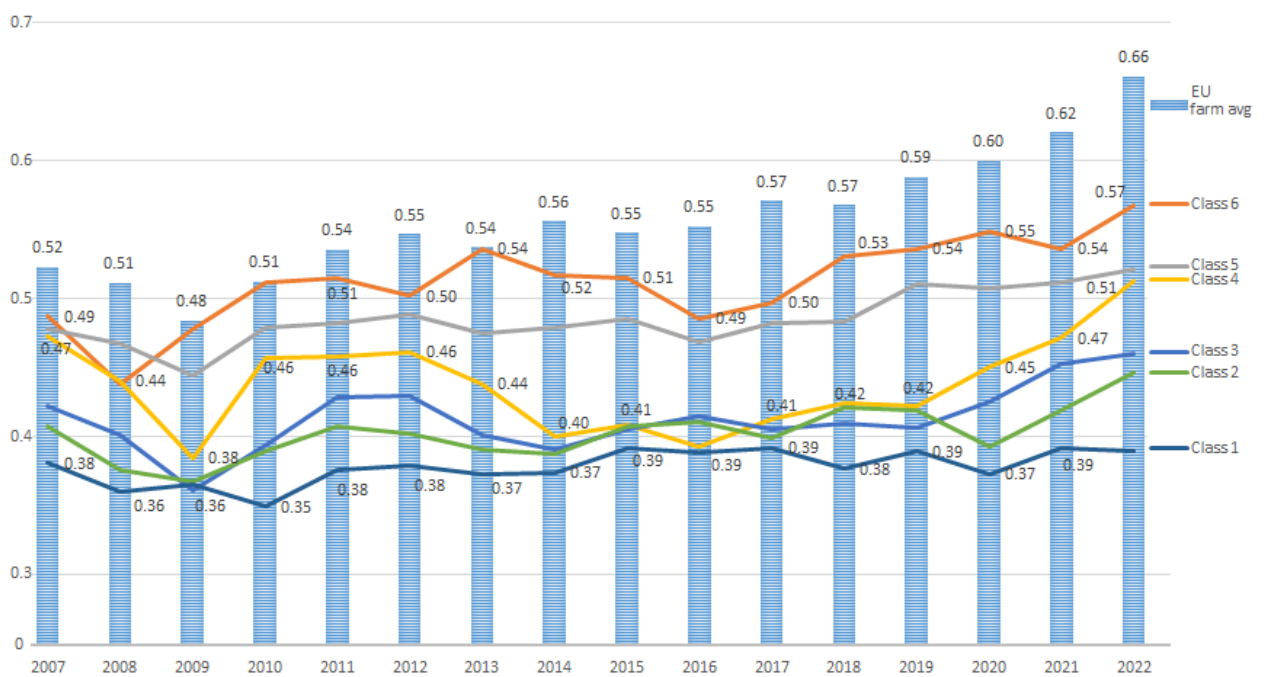


Fig. 2. European Development Framework to Measure Farm Social Sustainability estimated by the Relative Comparative Assessment Method

Source: Own Calculations Based on FADN.

Ecological Farm Sustainability

The ecological field crops indexation is expressed mainly by the detrimental production inputs, which involve their values being presented upside down. The EU policy aiming at the reduction of fertilization and crop protection costs at the end of the covered period is about to fail if the mentioned costs do not cover the increasing share of organic inputs. The only exception is presented by the smallest farm size (Fig. 3) despite their short-term progress.

The 2008 worsening indicator values of all social sustainability indices might be caused by the adaptation to the CAP's new schemes. Furthermore, CAP member states` management might be responsible for the following improvements by spending significant resources for a short- to mid-term plan, after which the lack of funding will lead to drop downs (which are even more depressing compared to the first applied policy) until the next program schemes. Almost the same is the farm environmental attitude during the second surveyed CAP period. However, some exceptions appeared – the beginning starts with an increase and ends with a rise (despite ESC 1, which might be more flexible). The end of that period is also covered by the same EU policy (no change of the CAP measures until 2022), but the calculations may be affected by poor funding and keeping the new eco schemes afterward.

Farmers who benefit more from CAP funding also have more resources to spend on detrimental production factors, leading to worsening ecological performance in that classical construction of farm sustainability, leading to fluctuating ecological policy on the farm level, strictly connected to the budget management of the payment agencies in the prevailing part of the MS.

Compound Farm RCA Sustainability

The only positions where the Compound Sustainability Index is above the EU farm average is connected with Class 4 &5 at the beginning of that time interval – 2007 (Fig. 4). It reveals a tar-

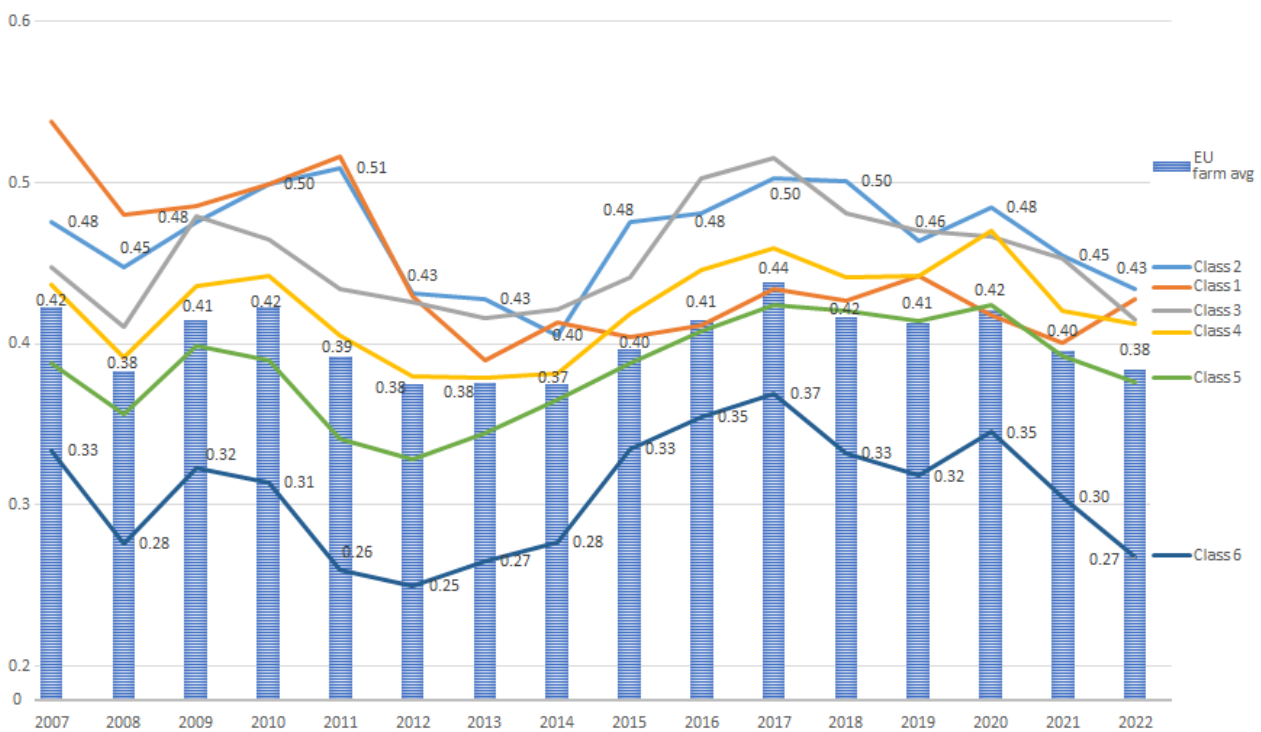


Fig. 3. European Development Framework to Measure Farm Ecological Sustainability measured by the Relative Comparative Assessment Method

Source: Own Calculations Based on FADN.

geted position of the smallest scale farmers who suffered the area payments injustice, while the other ESC framers are being strengthen – ESC 4, ESC 5 and ESC 6 at the highest level in 2022, while ESC 2 and ESC 3 are lower but increasing. In contrast, the smallest farm size class is significantly below the starting point in 2007.

The starting point of the compound sustainability level of the fourth and fifth ESC was reached, respectively, in 2019 and 2021. The highest agricultural holding class is upgrading its level during the second policy period, which means the CAP is not supporting equally their sustainability levels.

Almost the same is observed in the smaller size classes. Second and third ESC are experiencing peaks, but those levels are closer to their starting point in 2011 and 2017 – 2018; however, the results put them in a non-favorable situation covered by a massive loss of farm entities.

The smallest farmers follow the same pattern, but until 2011. Afterward, they could not recover their sustainability dimensions, which led to leaving behind the common increasing trend. That means CAP does not care about the small farmer anymore. That is coupled by a lack of support in the policy after 2022, by fixing the support to a certain level without even subsidizing the area anymore, but only the farm itself at a very insufficient level.

RCA indexation reveals how the larger holdings could make expenditures to intensify their productivity at a cost of environmentally unfavorable inputs, protecting their harvested yields and improving their income when CAP "green" goals step back when there is no additional support, which is expected after 2022 (so-called eco-schemes). However, this type of modeling is not able to correctly evaluate the effects of "green" measures, keeping the proximate indicators of costs on fertilizers and pesticides.

Efficiency Estimation on Sustainable Policies by Data Envelopment Analysis

Economic CAP Efficiency on Farm Sustainability

Data Envelopment Analysis, as an economic tool measuring the technical efficiency of deci-

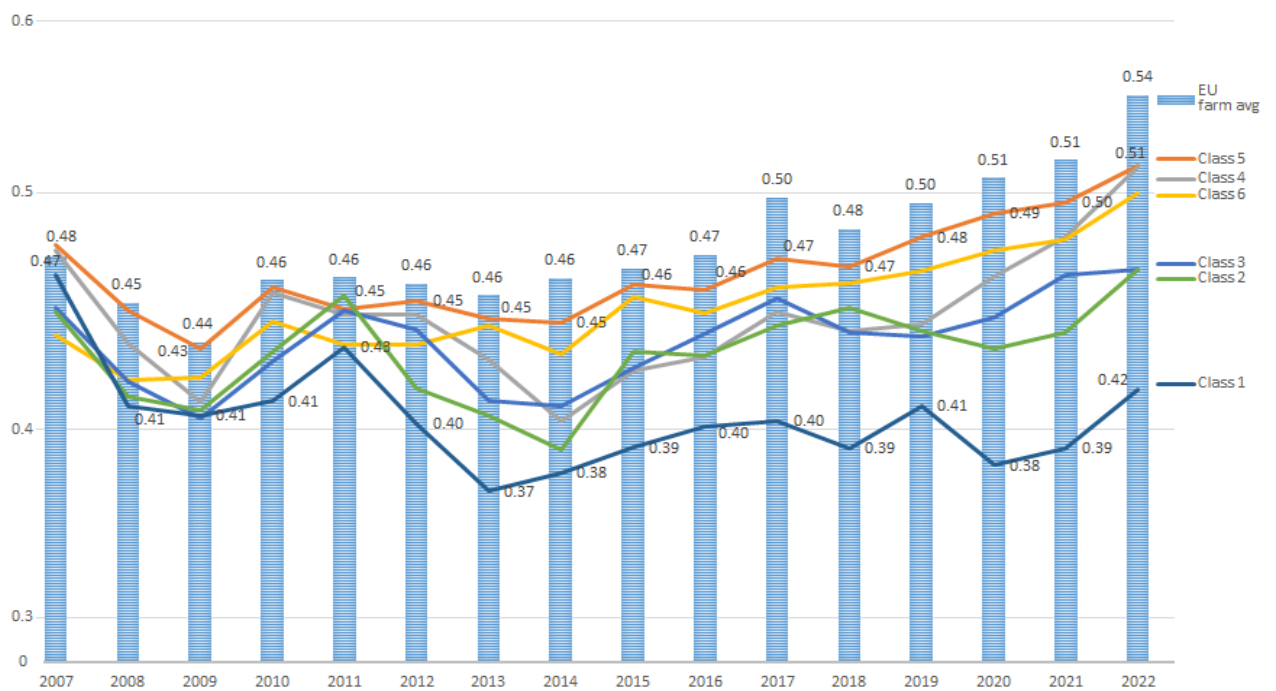


Fig. 4. European Development Framework to Measure Farm Compound Sustainability estimated by the Relative Comparative Assessment Method

Source: Own Calculations Based on FADN.

sion-making units (DMUs), also measures the efficiency of production scale. Furthermore, the higher the scale economies are, the higher the measured efficiency is (Fig. 5).

Such a difference between the evaluated technical efficiency of the two highest economic size classes (5 and 6) stands for production scale inequalities, which also covers an interpretation of the CAP area payments. This circumstance might be explained by the difference between the total utilized agricultural area of those average farm classes, which is more than 4 times (Table 1), and is defined by the missing upper border of the largest economic size class. These obstacles lead to a more than 2.5 times higher efficiency rate in favor of ESC 6.

On the other hand, the difference between all other farm classes (where upper and lower borders are available) is about 2 times in the production area, and the area payments have an insignificant impact on the CAP efficiency according to the current method.

In 2016 the curve of ESC 2 pass through the lines of ESC 3 and ESC 4 which is up to a major change in France due to an almost doubled labour input (from around one up to almost 2 AWUs) causing four times increased gross farm output where the mean values of the other production years in about 24 thousand euro while the current year is extended to almost 96. This makes it one of the cases called "virtual producers" or the pattern of the comparison in the model (virtual producer). Such a breakthrough leads to a predominance of the ESC 2 above the higher one until 2021, when the status quo was recovered.

Afterward, the farm production scale, accompanied by the area payments, is crucial for ordering the diversity of farm size classes in a row

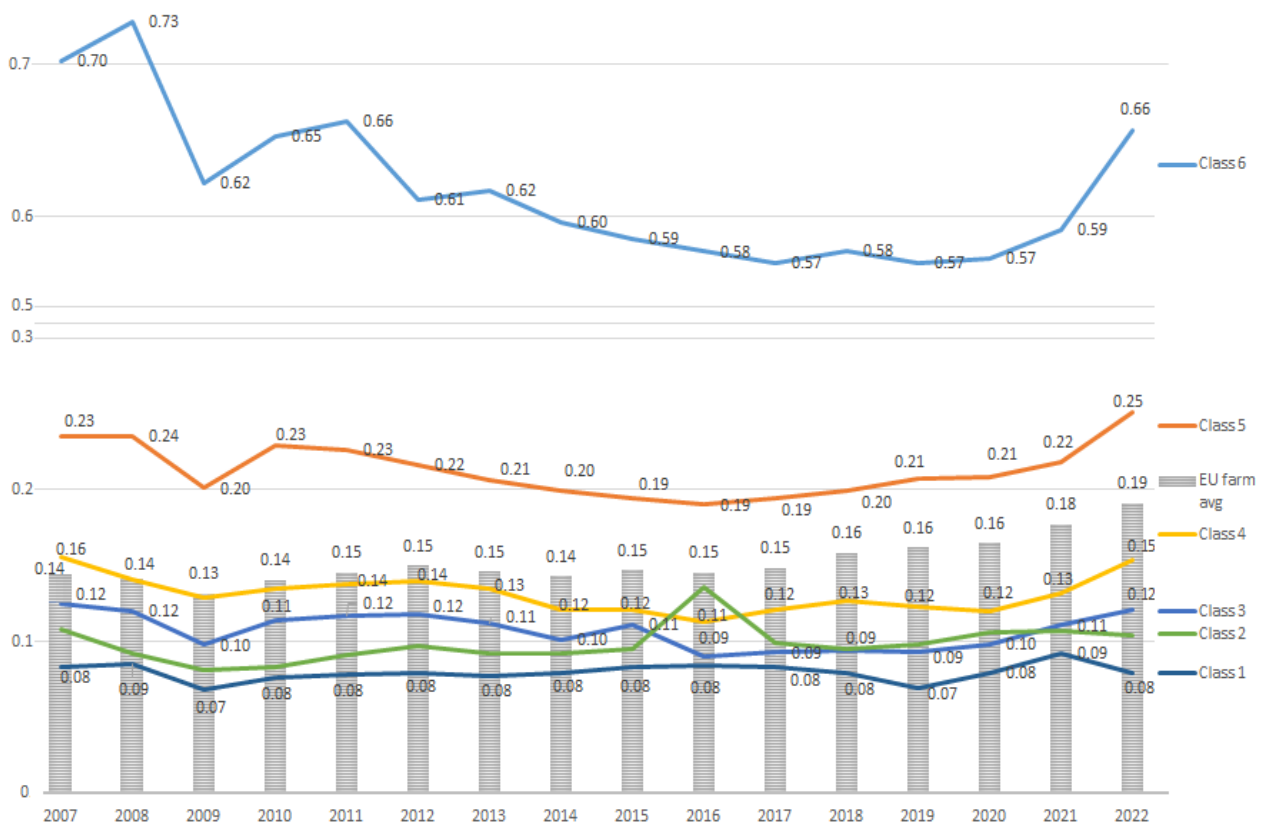


Fig. 5. European Development Framework to Measure CAP Policy Efficiency on Farm Economic Sustainability estimated by Data Envelopment Analysis (Benefit of the Doubt) Method

Source: Own Calculations Based on FADN.

from ESC 1 to ESC 6 without any surprise. First class has the lowest policy efficiency score, while the largest holdings are the most efficient.

As a conclusion, the DEA efficiency scores are not correlated to inflation and consider only the optimization of the economic performance.

Social CAP Efficiency on Farm Sustainability

Concerning the social values in terms of policy efficiency, the smallest farm size has no change in its behavior. The minor fluctuations (2009 & 2017) are just expressing a lower gross output, which might be caused by lower market prices and/or poor harvested quantities.

On the other hand, the difference in performance of ESC 2 to ESC 4 is as small as the difference in their production scale. Especially during the second inspected program period (after 2014), their efficiency curves are frequently equilibrating each other until 2022, where ESC 4 is separated to a higher level following the common EU trend, as well as ESC 2, while the one in between is declining.

The curve of ESC 5 follows (or maybe models the pattern of) the rate of EU farm average. This statement put those farms among the acceptable sustainability level, passing through the needed level of feeling "secured" by the policy.

The largest ESC social performance reveals exactly to whom CAP should be designed. This expression is very clear after 2020, when there are no such values before, as the final score in 2022, and is almost doubled compared to the non-changing first economic size class. Compared to the Relative Comparative Assessment, the social sustainability (efficiency) level of the largest farm class is quite higher than the EU farm average. This is caused by much improved productivity of labor (from 68,722 to 129,258 euros per AWU) and capital (0.46 to 0.65) based on a higher production scale, scale economies, and production intensity.

Ecological CAP Efficiency on Farm Sustainability

The efficiency scores of the ecological optimization strongly differ compared to those received by the Relative Comparative Assessment.

It might be easily seen how the RCA is accumulating the indicators to form an index, while

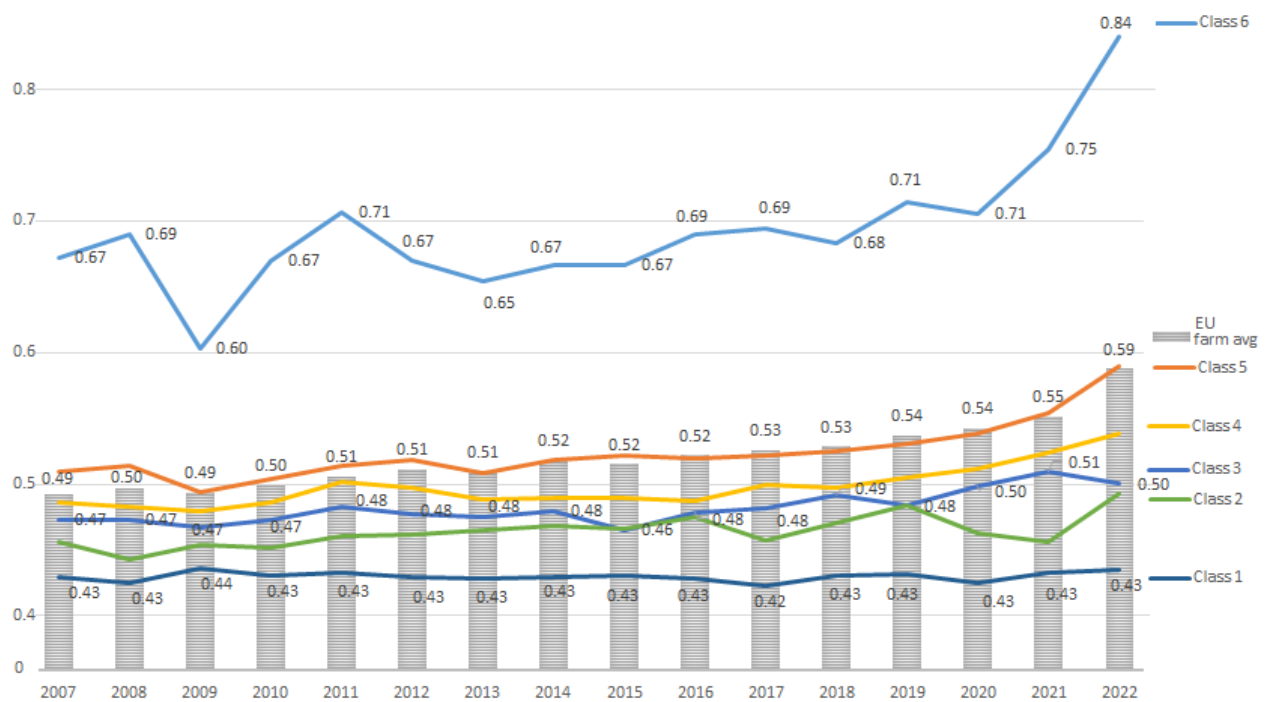


Fig. 6. European Development Framework to Measure CAP Policy Efficiency on Farm Social Sustainability estimated by Data Envelopment Analysis (Benefit of the Doubt) Method

Source: Own Calculations Based on FADN.

the DEA is estimating the efficiency of the main detrimental inputs, energy intensity, and good agricultural practices.

This methodological circumstance is demonstrated very clearly in the ESC 6 curve, where the RCA result is at the lowest level, which stays for very high input values, while their effects are shown in Figure 7 as the most efficient of all farm classes and far above (3 times) the second-placed ESC 5, which is also above the EU farm average. This means that those inputs result in significant yields and high productivity.

Another interesting finding is how ESC 2 increased its ecological farm sustainability in 2017 – 2019 (on Figure 3), which is also resulting in an above EU farm average score on Figure 7, which stands for a balanced ratio between production scale, inputs, and the received farm output. Such a trend is observed in ESC 4 results, where this dependency is available during the second inspected period after 2014.

Esc 1 and ESC 3 share common lines in both used comparative tools, but their efficiency is below the benchmark for most of the covered time period.

15-Indicator CAP Efficiency on Compound Farm Sustainability

Concerning the RCA method, all the measured sustainability rates of field crop farms` classes are below the EU farm average (on Fig. 4), while the CAP efficiency rates of ESC 5 and furthermore ESC 6 are following the EU farm average tendency and are also above the comparative benchmark on Fig. 8.

ESC 4 is following the benchmarking values as a trend but at a slightly lower level, which seems quite efficient, keeping in mind a smaller production scale and, respectively, the rate of CAP support.

Every time the ESC 3 line presents a height, it is permanently passing through each of its previ-

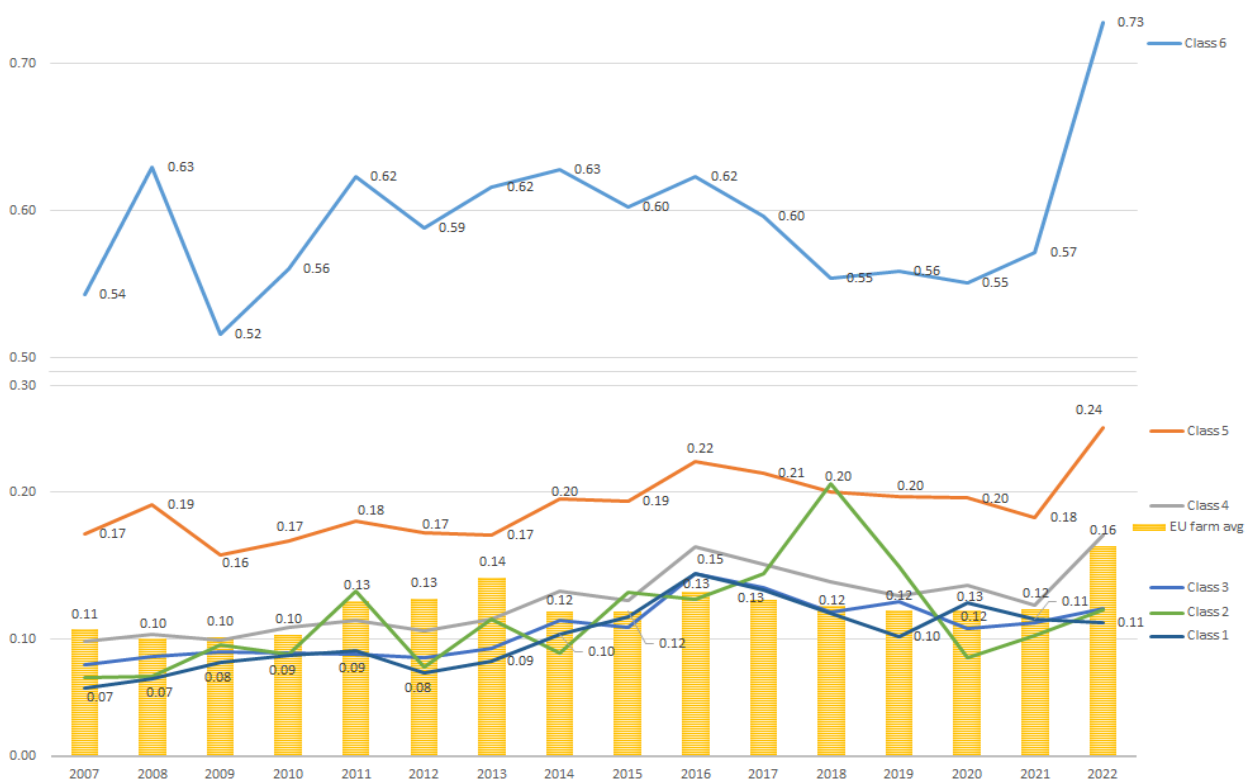


Fig. 7. European Development Framework to Measure CAP Policy Efficiency on Farm Ecological Sustainability by Data Envelopment Analysis (Benefit of the Doubt) Method

Source: Own Calculations Based on FADN.

ous values. This happened in 2011 after exceeding the level of 2008, in 2014, 2016, and finally in 2021, which means it is expressed as a sinusoid that marks a positive trend of development.

The reason for the increase in ESC 2 in 2016 is the same as that of the Economic CAP efficiency, but the case of ESC 1 in 2018 is not visible on any of the previous graphics. Keeping in mind that the complexity of DEA modeling is much deeper (the indicators are triple that of the pillar estimations), this means that the total DMU's performance is significantly improved on a total performance basis.

Composite Farm Sustainability Indexation

Composite Economic Index on Farm Sustainability

The Composite Economic Index (combining the results of both estimation methods) of the field crop farms summarizes the results of previous figures and follows the common sustainability development trend of average farm sustainability or the combination of all the inspected different farm specializations. All of them are struggling with the transition of policy implications on the new CAP schemes, respectively, in 2009 and 2014. The EU farm average is stagnating over a longer period (no significant increase to 2019), where the minimum values of their economic sustainability rates are measured (Fig. 9). This tendency might be much more threatening to the other farms' specialization and should be observed in further publications.

Agricultural holdings succeeded in recovering from such a stress period at the end of the observation (ESC 1, as an exception, could not). During a significant part of the two surveyed mid-term CAP implementation periods, most of the agricultural enterprises even managed to overjump their initial values. This happened at a cost of an important decrease in the number of farms in all EU member states except the Czech Republic (Eurostat, 2023).

Keeping in mind that most of the time the economic sustainability indexations have lower values and their peaks are provisional, it might be

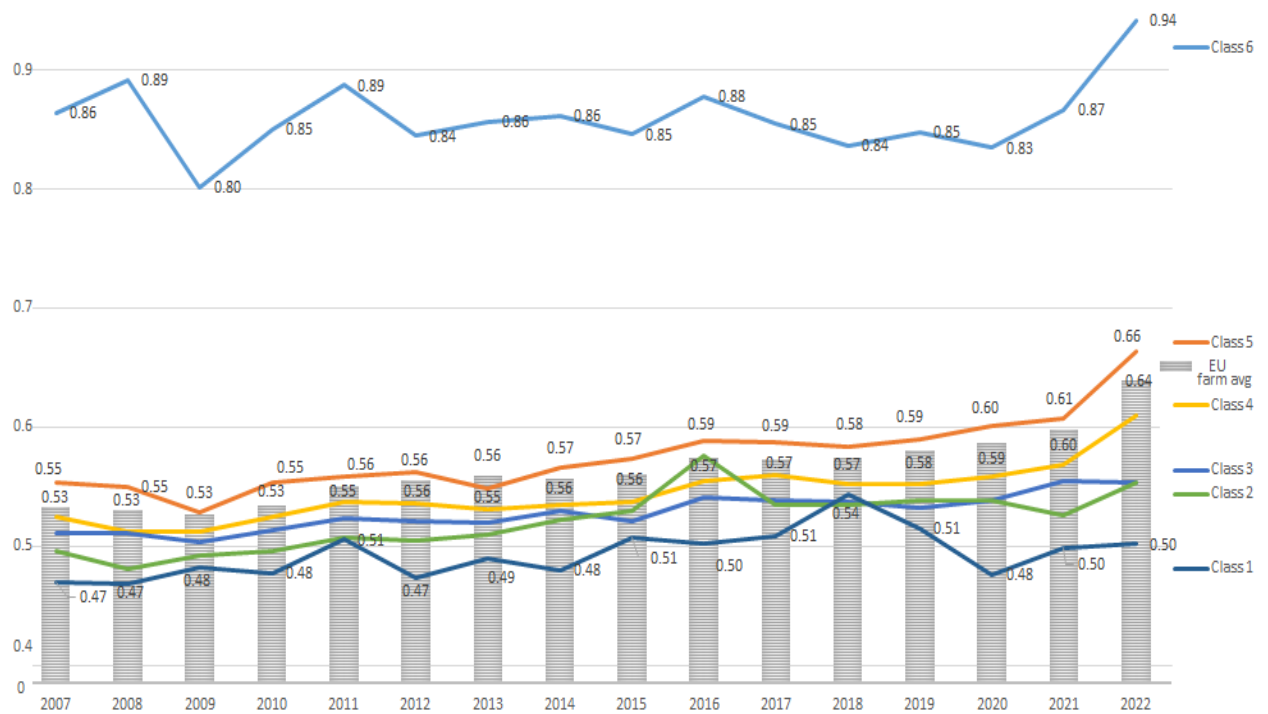


Fig. 8. European Development Framework to Measure CAP Policy Efficiency on Farm Compound Sustainability estimated by 15-indicator Data Envelopment Analysis (Benefit of the Doubt) Method

Source: Own Calculations Based on FADN.

summarized that the policy execution also costs a huge challenge to the entrepreneurs to survive economically and furthermore, a firm's social and ecological functions are dependent not only on a policy, but also on the initial production activity and farm managing skills.

Composite Social Index on Farm Sustainability

As opposed to the economic one, only the Composite Social Index of ESC 6 is above the EU farm average. However, the social reference level is substantially on a higher scale (Fig. 10), which confirms the declared high standards of the EU social policy in the rural area.

On the other hand, the support for the farm area unit pushing the highest economic size class is giving larger areas in the hands of a smaller labor force, which is in favor of improving labor productivity. The smallest economic size class might involve more than 10 farmers in cultivating 100 ha of arable land (Table 1), the second one would provide almost five persons (4.8), and the last important comparison is of ESC 3 where almost 3 annual working units might be (self) employed managing a hundred hectares of farm area.

The other three economic size classes need between 1 and 2 AWU for processing the above-mentioned amount of agricultural land.

This might be seen as a depopulation effect of the Common Agricultural Policy in applying the single area payment ideology.

So, the labor productivity, including large farm size and the area payments, might be in conflict of interest with the preservation and detention of social capital in the rural areas. Of course, the social standard that might be ensured in a settled rural society might be at a lower level, but there are still a sufficient number of small farming systems that are "playing the game".

If the attention of CAP is more concentrated on such a point, its budget would be distributed more fairly, the level of social sustainability of the rural society would be on a higher level, keeping the local people on their root land and

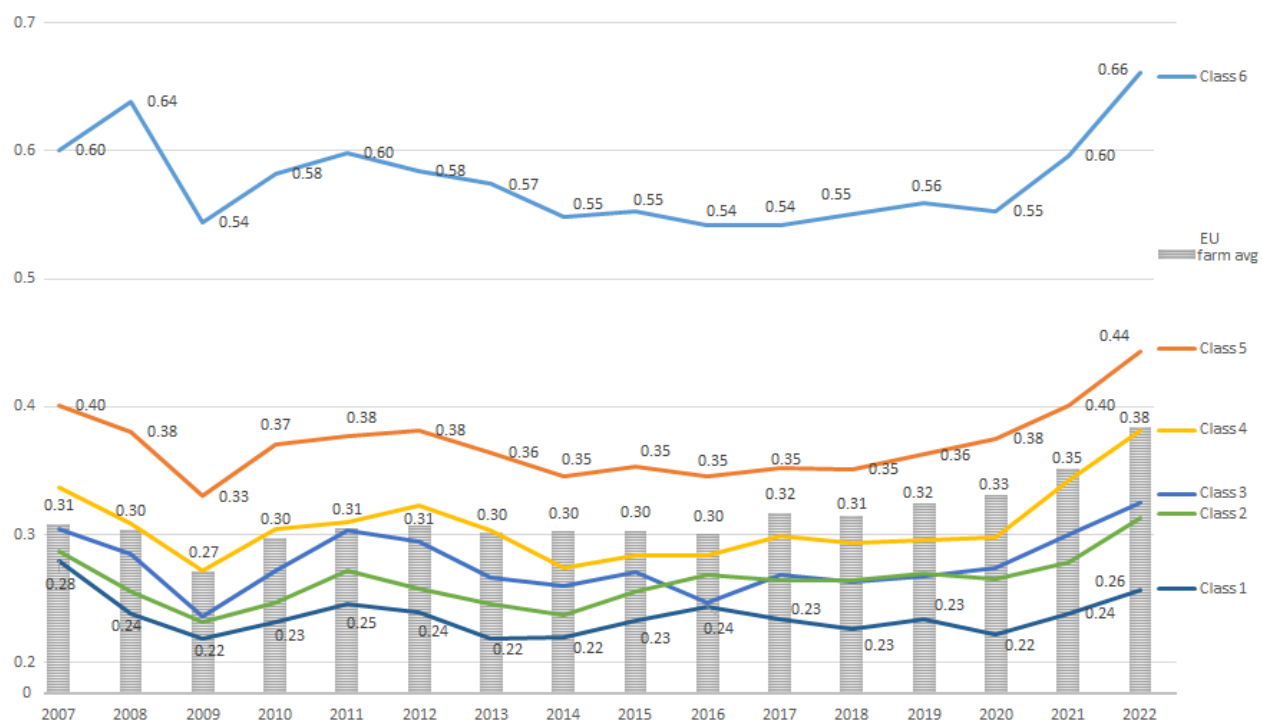


Fig. 9. European Development Framework to Measure Economic Farm Sustainability estimated by the Composite Method

Source: Own Calculations Based on FADN.

not pushing them to find new jobs in the overcrowded settlements.

Composite Ecological Index on Farm Sustainability

The Composite Ecological Indexes of field crop farms are expressed by an average mean value of indices measuring mainly the detrimental inputs and their effects on yields and the gross farm output. Their levels are mostly above the EU farm average, which stands for a comparatively good environmental management backed up by the CAP support and the national institutional implementations.

More environmental goals are delegated to the schemes of the second policy period, which is observed in the increased performance of all size classes. The impact of the CAP is divided into two types: the effect on most of the farm size classes is longer, while the largest ESC receives a bigger amount of the budget, but the influence is limited to 2018, followed by a decrease to the rate of 2010, and another sharp rise as a finish.

ESC 1 is a special case where the index volatility is high. Two peaks are expressed, once in the middle of each CAP program period – 2011 and 2018, but covered by a significant difference. During the first one, the environmental index sticks out above most of the other size classes (out of ESC 6), while during the second one, most of the time it is not at the top of the second CAP. This trend is solidified exactly between those two peaks. Such a temporary appearance distinguishes CAP as not interested in the development of that farm class.

The development in ecological terms of ESC 4 and ESC 5 is strengthened after 2014 when the CAP became more "green", which is common to ESC 2and ESC 3 behavior, but not that intensive and long-lasting.

Composite Sustainability Index

The efforts of the European Commission to establish a much more sustainable agricultural system through an improved policy scheme and implementation have gained varying success de-

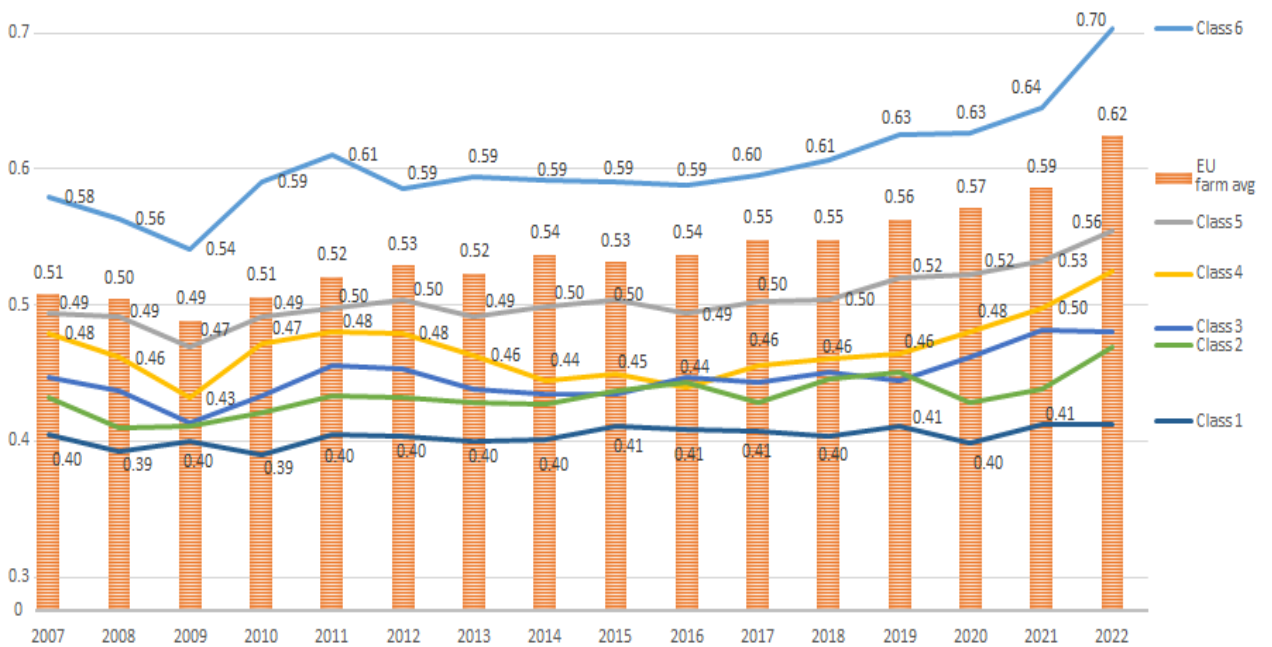


Fig. 10. European Development Framework to Measure Social Farm Sustainability estimated by the Composite Method

Source: Own Calculations Based on FADN.

pending on the farm size. The smaller a farm scale is, the lower the increase in sustainable development is, according to Figure 12.

The highest ESC is on a very high sustainability level, far above the EU farm average, while ESC 5 is a heavy part of the EU reference.

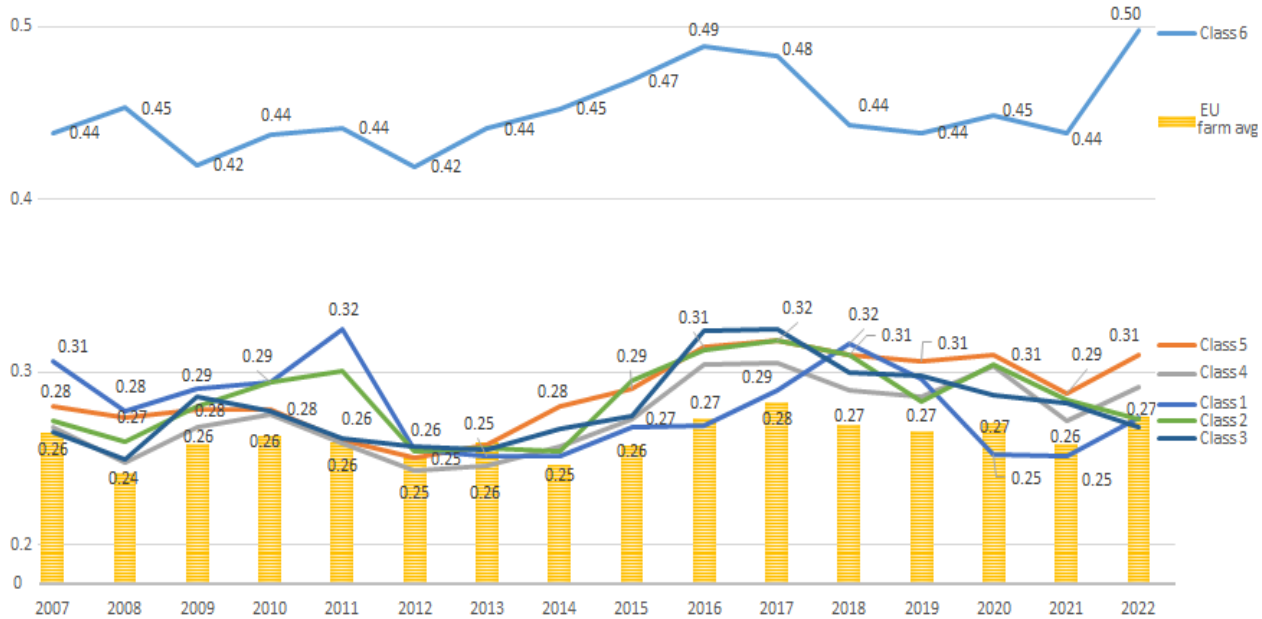


Fig. 11. European Development Framework to Measure Ecological Farm Sustainability estimated by the Composite Method

Source: Own Calculations Based on FADN.

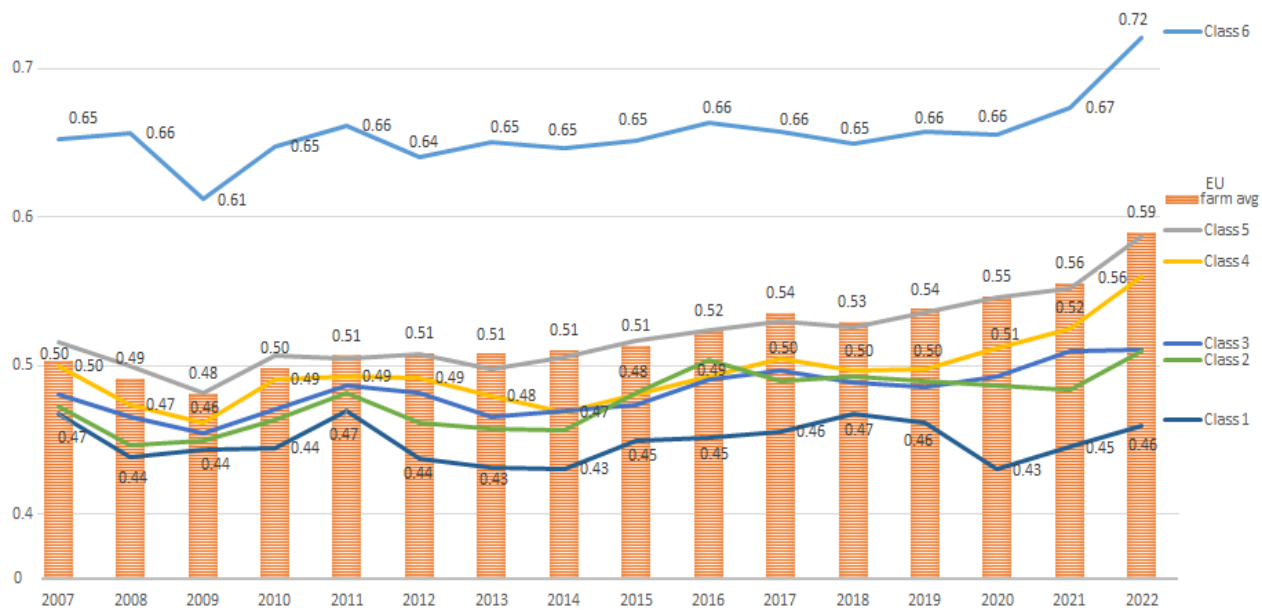


Fig. 12. European Development Framework to Measure Composite Farm Sustainability estimated by the Composite Method

Source: Own Calculations Based on FADN.

An essential increase is measured in the performance of ESC 3 and ESC 4, where each subsequent growth is higher than the previous one.

It would not be fair to say that the smallest farm class earned something out of the last two CAP schemes. The measured peaks of the Composite Sustainability Index are the same as the starting point, and no increase is detected.

CONCLUSIONS

Economic and Social sustainability are sharply dependent on farm economic size and production scale. This might also be noticed in the ecological sustainability performance, but the dependency has an inverse proportionality.

That composite indexation is built based on a comparative approach and is not sufficiently classified to the degree to interpret the implications of the results as if a farm size class is sustainable or not. This study aims to provide a framework to assess the farm sustainability of different MS and to give a picture of the level of cohesion and coherence development of EU policy.

It is found that almost all of the Economic Size Classes gain an increase in the sustainability indices. But, that happened at a cost of a significant loss of farmers, no matter if they are market-oriented or not, they used to produce food and to keep the population density of rural areas high, to maintain and spread traditions, and so on.

The small-scale farms covered by the FADN turn out not to be among the successful ones in terms of economic, social, and compound sustainability, which is based on the area support. However, on the other hand, the smallest market farms are among the most conscious in keeping environmentally friendly agricultural practices. Keeping in mind that most of them are managed by self-employed owners of production factors (a middle class), they are estimated to be efficient and sustainable. All factors for sustainable development are quite dependent on the farm management and uncontrollable by human factors, but on the other hand, the public policy continues to play a crucial role in the implementation of the policy goals. CAP improved the economic performance of farms to a great extent, but at the same time, it affects their resilience to be vibrant in the future (potentially) without subsidies.

The conflict between the ecological and the economic performance is obvious, as it reveals the contest between the extensive farming practices and the massive agribusiness entities that intensively exploit the limited soil productivity.

The production modesty, social, and ecological merits are distinctly noted in the small-scale farms. Each policy should take the choice of how to preserve the land resources for the next generation and describe sustainable development as its own challenge, opportunity, and policy goals.

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