Indicators for the economic dimension of sustainable agriculture in the European Union

Gábor Valkó

Hungarian Central Statistical
Office
Budapest, Hungary
E-mail: Gabor.Valko@ksh.hu

Mária Fekete-Farkas

Szent István University
Gödöllő, Hungary
E-mail:
Farkasne.Fekete.Maria@gtk.szie.hu

Ildikó Kovács

Budapest Business School,
University of Applied Sciences
Budapest, Hungary
E-mail: Kovacs.Ildiko@uni-bge.hu

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Over the past decade, the concept of sustainable development became inevitable on assessing economic, social, and environmental processes. Although the concept of sustainable agriculture also includes environmental and social aspects, the economic facet is still important for decision makers and researchers because of the increasing needs of the worldwide growing population. Moreover, the economic dimension of agriculture is also important because agriculture viability and compatibility are key determinants of its future. Consequently, we compiled an indicator system on the agricultural sustainability based on statistical data, which describes four dimensions of agriculture sustainability (food supply, environment, economy, and society). The indicator system consists of 44 indicators and can serve as a basis for developing composite indicators. Based on the indicator system and the composite indicators of the performance of EU countries, this study analyses economic dimension of EU agriculture (12 indicators). The results allow spatial comparisons and monitoring development over time. The performance of Hungary in terms of the economic dimension of sustainable agriculture is then analysed in comparison with its regional competitors.

Introduction

The concept of sustainable development was defined by the Brundtland report (Our Common Future), in 1987. Complementary to the Lisbon agenda, the EU adopted an equally ambitious Strategy for Sustainable Development (SDS) at the Gothenburg Summit, in 2001, which was to underpin all EU policies and actions. However, a number of unsustainable trends have worsened since 2001.

Agriculture is a special branch of the economy. Agricultural production is a nature-related activity, and has significant impact on the state of the environment, while also being an integral part of rural life. On one hand, it has remarkable influence on rural areas and, on the other hand, it is dependent on them in many aspects.

Agricultural production is multi-purpose as there are economic, environmental, and social roles of agriculture (OECD 2001, Boody et al. 2005, Rossing et al. 2007, Feher–Beke Lisanyi 2013, Królczyk et al. 2014, Huang et al. 2015). The main task of agriculture is food and fibre production, which describes both its productive or economic functions. Over the past decades, new tasks related to the economic function came to the fore, including controversial biofuel production (Fekete–Farkas et al. 2011, Popp et al. 2014). The profitability and viability of agricultural activities is vital. To achieve this, the production efficiency and competitiveness of the entire sector are essential.

Earth's growing population requires a large amount of surplus production of food. As such, the increase of utilized agricultural areas and/or of production efficiency are inevitable if consumption patterns remain unchanged. Therefore, the efficiency and economic dimension of agriculture sustainability are emphasised compared to the sustainability of other economic sectors. Although consumption is generally harmful to the environment (Kovács 2016), production and consumption of food are inevitable for life.

Indicator system of sustainable agriculture

A reliable indicator system describing sustainability becomes a pronounced requirement of decision-makers. Moreover, there is also an intensified expectation from the public to gain information on social and economic processes in terms of sustainability. Numerous organizations and scientific institutions have developed indicators and indicator systems that measure the performance of agriculture in terms of sustainability (e.g. MAFF 2000, INEA 2002, Valkó–Fekete–Farkas 2014). However, they are not fully adapted to Hungarian and European Union agriculture, most covering national context and not allowing spatial comparisons. These sets of indicators including numerous indicators do not provide a comprehensive picture. Consequently, there is a need for an indicator system that provides easily understandable information even on complicated, multi-dimensional issues such as sustainability. Besides, agriculture-related indicators are underrepresented in the indicator systems for sustainable development created by the United Nations and Eurostat.

There is a need for an indicator system that describes agricultural production of EU member states in terms of sustainability and is also capable of evaluating certain sustainability areas, thus presenting results, based on composite indicators, that are easy to communicate. This type of indicator system has not yet been developed for

the EU. The indicator system presented in this study is based on statistical data and can serve as a basis for producing composite indicators describing sustainability domains. It can also compare the sustainability performance of individual countries and monitor development over time; however, it obscures regional differences within a country. The indicator system has been validated by Hungarian and international experts with expertise in the sustainability of agriculture by filling in questionnaire aiming at the determination of the weights used for the development of composite indicators.

The theoretical framework of the indicators of sustainable agriculture in this study was built on a definition of sustainable agriculture from synthesising literature sources. The sources for the creation of the definition include: EU 2012, Farkasné Fekete et al. 2004, Kirchmann–Thorvaldsson 2000, National Research Council 2010, OECD 2001, RISE 2016, SARE 1997, Smith–McDonald 1998, Takácsné György et al. 2008, USDA 1999, Valkó–Farkasné Fekete 2014, Van Cauwenbergh et al. 2007.

The four points of the synthesised definition identified the domains of the indicator system, which are as follows:

- production of good quality, safe, and healthy foods; satisfaction of needs–food supply;
- conservation of natural resources, protection of the environment, creation of animal welfare–environment;
- efficiency, competitiveness, economic viability, ensuring profitability–economy;
- improving the quality of life in rural areas, social justice, and development of attractive rural landscape–society.

Methodology of developing composite indicators for the sustainability of agriculture¹

For the design and execution of the research, the ‘Handbook on Constructing Composite Indicators’, released by the OECD (2008), was used. According to the theoretical framework, 44 indicators were chosen and elaborated for the four domains. However, in this study, only the domain Economy is analysed, with its 12 indicators. Only the indicators for which data are available for EU member countries during 2000–2012 were selected. The data source for the Economy was the Eurostat database. Nearly 15 thousand data items were gathered for the entire indicator system, followed by data checking and editing, as well as the input of missing data. All phases of the process were carried out in a planned way, the most appropriate imputation method for the particular data type being used. Through the phas-

¹ The research that serves as a basis for this article was carried out during 2013–2015 by Gábor Valkó, and the results were compiled in his PhD dissertation (Valkó 2015).

es of indicators' selection and collection of basic data, the quality requirements developed by Eurostat and OECD were followed (Eurostat 2011, OECD 2012). The time series for 2000 to 2010 were used for analysis. An examination of the relationship between indicators using correlation matrices was carried out prior to finalizing the indicator system. The correlation matrices were compiled using the Pearson correlation test on the 2010 data, separately for the four domains and for the entire indicator set. The relationships between individual indicators can be explained. However, the number and strength of these relationships are not such that would reduce the reliability of the indicator system. Based on correlation analysis, the inclusion of each indicator in the system is reasonable (Table 2 includes the indicators for the domain Economy).

To develop composite indicators, the normalization of indicator system data was carried out using the min-max method, with the application of the following formula (OECD, 2008):

$$I_{qc}^t = \frac{x_{gc}^t - \min_{t \in T} \min_c (x_q^t)}{\max_{t \in T} \max_c (x_q^t) - \min_{t \in T} \min_c (x_q^t)},$$

where

x_{qc}^t = value of indicator q for country c and year t ;

I_{qc}^t = normalized value of indicator q for country c and year t .

The weights required for the calculation of the composite indices were determined by expert opinion. In the literature (OECD 2008), this procedure is referred to as the budget allocation process (BAP). During this process, experts distribute 100 points for the indicators according to their importance, in terms of the target determined by the theoretical framework of the indicator system. Determination of weights is complex, and it is difficult to make an informed decision because of the too many circumstances to be considered and the limited information. For this reason, the experts who had difficulties in the distribution of 100 points were offered to determine the rank of indicators in terms of their contributions to the sustainability of agriculture. The opinion of the experts giving ranks was processed by converting the ranks to weights using the following formula:

$$w_i = \frac{r_{\max} - r_i + 1}{\sum_{i=1}^n r_i},$$

where

w_i = weight of indicator I_i ;

r_i = rank of indicator i .

The aggregation of indicators was performed using linear aggregation by adding the normalized and weighted values of the indicators according to the formula (OECD, 2008):

$$KI_c = \sum_{q=1}^Q w_q I_{qc} ,$$

where

$$\sum_q w_q = 1 \text{ and } 0 \leq w_q \leq 1 \text{ for all } q = 1, \dots, Q \text{ and } c = 1, \dots, M;$$

KI_c = value of composite indicator for country c ;

w_q = weight of indicator q ;

I_{qc} = value of indicator q for country c .

The weight system of the composite indicators was developed using the results of an expert survey. The survey research was carried out between 28 October 2014 and 6 January 2015. Questionnaires were sent to a total of 102 experts (including international experts), with expertise in sustainability of agriculture. Of these, 60 experts returned the questionnaire, representing a return rate of 59% (Table 1); 65% of the respondent experts held at least a PhD degree and the rest at least an MSc.

Table 1

Number of questionnaires sent out and received during the expert survey

Expert	Number of questionnaires sent	Number of questionnaires received	Return rate, %
Hungarian expert	60	41	68.3
International expert	25	12	48.0
Expert from an international organization (outside Hungary)	17	7	41.2
Total	102	60	58.8

Source: own research.

When compiling a composite indicator system, a number of subjective decisions have to be made, which may substantially influence the composite indicator values. Therefore, the robustness and reliability of the composite indicators were measured using sensitivity analyses for the following areas: compilation of indicator system, type of weighting system, and expert selection. The values of the key composite indicator for the sustainability of agriculture calculated with modified conditions were then compared with the results from the original method. Based on the results, only the selection of the type of weighting system influenced significantly the values of composite indicators.

Research results

Indicator system of sustainable agriculture

The established system of indicators for the economic dimension is shown in Table 2. Twelve indicators were chosen of the indicator system and were grouped in two sub-groups so that the importance of the indicators could be assessed more easily by the experts.

Table 2

Indicators of domain economy of the indicator system for sustainable agriculture and their weights

Theme	Indicator	Unit	Goal*	Weight
Efficiency, competitiveness				
Resource use	Output per intermediate consumption in agriculture	-	+	19.3
Efficiency of land use	Gross value added per hectare of utilized agricultural area	EUR/ha	+	21.8
Labour productivity	Gross value added per labour input in agriculture	1000 EUR/annual work unit	+	20.5
Competitiveness in foreign trade	Ratio of exports and imports of agricultural products	-	+	14.2
Yields	Yields of cereals	100 kg/ha	+	13.7
Utilization of agricultural land area	Share of unutilized agricultural area as a percentage of total agricultural area	%	-	10.6
Economic viability, profitability				
Replacement of means of production	Gross fixed capital formation per consumption of fixed capital in the agriculture	EUR	+	15.3
Diversification of production	Standard output of farms with non-agricultural activities as percentage of total standard output	%	+	15.7
Research and development	Research and development in agriculture EUR 1,000 of gross value added	EUR	+	17.3
Age composition of farmers	Ratio between percentage of farmers below 35 and 65 or older in terms of standard output	-	+	13.5
Agricultural income	Agricultural income – indicator ‘A’	2005 = 100	+	22.4
Subsidy dependency	Agricultural subsidies in percentage of gross value added	%	-	15.8

* ‘+’ means a maximization goal, while ‘-’ means a minimization goal.

Source: own research.

Indicator system of the economic dimension of sustainable agriculture

Within the sub domain 'Efficiency and competitiveness', the largest weights were assigned to the indicators of efficiency of land use, labour productivity, and resource use (Table 2). The utilization of agricultural land area was, however, considered the least important one by the experts. The standard deviation of the evaluation of each indicator for labour productivity was relatively high (10.8), while in the case of the indicators 'yields' (5.6) and 'utilization of agricultural land' (5.7), it was rather low.

The index of agricultural income was assessed as the most important from the sub domain 'Economic viability and profitability' (Table 2). There was a relatively high evaluation of the indicator 'R&D', while the lowest average weight was assigned to the 'age composition of farmers'. The standard deviation of each indicator was relatively low, the highest being the 'diversification of production' (9.1), while the lowest was R&D (6.0).

The sub domain 'Economic viability and profitability' was considered slightly more important (52.2) than 'Efficiency and competitiveness' (47.8) by the experts. A high proportion of experts (37.9%) assigned the same importance to both areas. The indices of the sub-themes had a moderate standard deviation (13.0).

Values of the indices in the domain 'Economy'

The composite index for the sub domain 'Efficiency, competitiveness' within 'Economy' is extremely high in the Netherlands compared to other member countries in 2010 (Figure 1). The Netherlands is followed by Spain and France, while Latvia, Slovakia, and Estonia had the least efficient agriculture in the EU in 2010 on the basis of index values. Hungary's performance is similar to that of Poland and Lithuania, but behind the EU average regarding the level of efficiency and competitiveness on the basis of 2010 figures. The Netherlands reached the highest values for land use efficiency and labour productivity, and the second highest index for foreign trade competitiveness and yields. Latvia, as a counterpoint to the Netherlands, had the lowest values for land use and work efficiency indicators.

The EU as a whole registered a 12% increase in the efficiency and competitiveness of agriculture between 2000 and 2010 on the basis of the composite indicator. The highest growths were detected in Finland (175%), Cyprus (80%), Latvia (78%), and Poland (50%), while the largest decrease took place in Ireland (27%) and Hungary (7%).

Figure 1

Values of index components for 'Efficiency, competitiveness'
in EU member states, 2010

Source: own calculation based on Eurostat data (Eurostat 2014).

According to the indicators for 'Economic viability, profitability' for 2010, Belgium reached the highest values, followed by Germany and Austria, while the lowest values were found for Ireland, the Czech Republic, and Slovakia (Figure 2). Belgium had the highest score in the EU in the areas of research and development and level of farm income, while for the diversification of farming only the Czech Republic had a lower value. Ireland performed generally poorly, except for diversification.

Figure 2

Values of index components for 'Economic viability, profitability'
in EU member states, 2010

Source: own calculation based on Eurostat data (Eurostat 2014).

The composite indicator for the sub domain 'Economic viability, profitability' increased most in Romania (46%), Poland (35%), and Belgium (33%) between 2000 and 2010, while decreases were registered in Ireland (42%), Italy (28%), and Bulgaria (24%). The growth in Hungary (10%) was above the EU average (4%).

The composite index of sustainable agriculture 'Economy' had the highest values in the Netherlands and Belgium in 2010, and the lowest in Ireland, the Czech Republic, and Slovakia (Figure 3). Poland is the only country of Central and Eastern Europe that had a higher indicator than the EU average. The composite index for –

'Economy' is shown in Figure 4. The two leading countries were the Netherlands, with the most efficient agricultural production in the EU, and Belgium, with the most viable and profitable agriculture in 2010.

Figure 3

Values of the index for the Economic dimension in EU member states, 2010

Source: own calculation based on Eurostat data (Eurostat 2014).

Figure 4

Values of index components for 'Economy' in EU member states, 2010

Source: own calculation based on Eurostat data (Eurostat 2014).

The composite index of the economic dimension achieved the highest growth in Romania (84%), Poland (80%), and Finland (71%), while it decreased most in Ireland (57%) and Italy (21%) from 2000 to 2010. The increase in Hungary was 8%, slightly below the average growth of the EU (11%). The 2010 values of the index and the relative changes in their values compared to 2000 are displayed in Figure 5.

Figure 5

Values of the index for 'Economy' and the rate of change compared to 2000 figures in EU member countries, 2010

Source: own calculation based on Eurostat data (Eurostat 2014).

Values of the domain 'Economy' for Hungary

Within the domain 'Economy', the indicator measuring efficiency and competitiveness for Hungary was significantly below the EU average in 2010 (Figure 6). The largest backlog was observed in work productivity, efficiency of land use, and resource use, while foreign trade competitiveness performed above the EU average. The composite indicator value slightly declined in Hungary between 2000 and 2010, while the EU average showed an increase. The deterioration of its relative position is primarily a result of the negative trend experienced in the field of foreign trade competitiveness and farmland utilization, while in the area of resource use, relative improvement occurred compared to the EU average.

The Hungarian index for the sub domain 'Economic viability, ensuring profitability' was below the EU average (Figure 7) for 2010. Hungarian agriculture showed a significant shortfall compared to the EU average for the age composition of farmers, supply of production equipment, and aid dependency. The indicator for R&D was, however, above the EU average. The changes experienced in Hungary between 2000 and 2010 do not deviate significantly from the EU average of the individual indices in direction and degree. The composite index moved closer to the EU average, over the 11 years under analysis, but it was still below it in 2010.

Figure 6

Source: own calculation based on Eurostat data (Eurostat 2014).

Figure 7

Values of indicators for 'Economic viability, profitability' in Hungary compared to the EU average, 2010

Source: own calculation based on Eurostat data (Eurostat 2014).

Hungary fell behind the EU average in terms of the economic dimension of sustainable agriculture according to 2010 figures, a lag rather resulting from the difference in 'Efficiency and competitiveness' than 'Economic viability and profitability' (Figure 8). The position of Hungarian agriculture relative to the EU average showed a slight deterioration in 'Efficiency and competitiveness' between 2000 and 2010, while there was a slight improvement in terms of viability and profitability.

Figure 8

Values of indices for 'Economy' in Hungary compared to the EU average, 2010

Source: own calculation based on Eurostat data (Eurostat 2014).

Comparisons with regional competitors are shown in Figures 9 and 10. The composite index of 'Economy' grew most for Romanian and Polish agriculture between 2000 and 2010 among the studied countries. The Polish agriculture reached a higher index value in 2010 than the one in Hungary, and caught up with Austria. It is worthwhile noting that the Romanian and Hungarian indices moved mostly together recently. The most significant growth was detected in Romania and Poland between 2000 and 2010, while data for other countries have not changed significantly, apart from the Slovakian index, which experienced growth between 2001 and 2008.

Figure 9

Indices of 'Economy' for Hungary and the regional competitors, 2000–2010

Source: own calculation based on Eurostat data (Eurostat 2014).

Figure 10

Changes of the indices for 'Economy' for Hungary and regional competitors, 2000–2010 (2000 = 100)

Source: own calculation based on Eurostat data (Eurostat 2014).

Discussion – Study limitations

The quality of the composite indices is influenced by the theoretical coverage of specific areas by relevant indicators supported by adequate quality basic data. For this reason, it is essential to improve the accessibility and quality of basic data for the scientifically sound examination of sustainable agriculture. An additional problem in many areas is long data production time, which also needs improvement. Creating indicators at a lower territorial level is currently not possible in many areas because raw data are not available, a deficiency that could be eliminated by applying proper data collection methodologies or estimation procedures that could enable the dissemination of data at a lower territorial level.

The most important difficulty related to composite indicators is the lack of their widespread acceptance. Their values can be significantly affected by the theoretical framework, scope in the indicator system, and methodology of the weight system essential for their calculation. In many cases, subjective decisions are needed for the development of an indicator system. However, the communication value and role of composite indicators in decision support are indisputable. It is necessary for a composite index that its methodology has appropriate political support, is laid for broad consensus, and is widely accepted.

The system of indicators and the related composite indicators in this research can support European and national agricultural policy decisions, as well as shape the Common Agricultural Policy and its components. They have a good communicating power, since the composites are easy to interpret for the general public. A distinct advantage of the indicator system is that it is suitable for the systemic tracking of changes in agricultural production, both at national and EU levels.

Conclusion

Based on a literature review, we compiled the definition of sustainability of agriculture, which served as a basis for the development of an indicator system for agriculture sustainability, based on macro data. The data for the indicators have been compiled for the EU member countries for 2000–2012. Based on the indicator system, composite indicators were then developed for the domains of sustainable agriculture. In this study, the domain 'Economy' is analysed using such composite indicators. Spatial and temporal comparisons make it possible to overview the processes in terms of the economic dimension of sustainable agriculture in EU member countries. According to the results, the composite index for 'Economy' had the highest values in the Netherlands and Belgium, while the lowest in Ireland, the Czech Republic, and Slovakia in 2010. The index value increased in the EU by 11% from 2000 to 2010. Romania, Poland, and Finland had the highest growth rate, while Ireland and Italy had the largest decrease in the EU. Hungary registered a growth rate (8%) below the EU average.

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