ANNALS OF THE POLISH ASSOCIATION OF AGRICULTURAL AND AGRIBUSINESS ECONOMISTS

received: 03.10.2019
acceptance: 04.11.2019
published: 15.12.2019

Annals PAAAE • 2019 • Vol. XXI • No. (4)

JEL codes: Q10, Q56

DOI: 10.5604/01.3001.0013.5565

ALDONA MRÓWCZYŃSKA-KAMIŃSKA

Poznań University of Life Sciences, Poland

AGRICULTURE AND THE ENVIRONMENT IN EUROPEAN UNION COUNTRIES IN LIGHT OF INPUT-OUTPUT TABLES[1]

Key words: sustainable development, agriculture, input–output tables, atmospheric pollutants, biomass

ABSTRACT. Due to the growing importance of sustainable socioeconomic development at a national level, this paper makes an attempt to identify and assess the relationships between agriculture and the environment in European Union countries in light of input–output tables. To meet that objective, data was retrieved from input-output tables and European environmental accounts. The analysis covered material input and output to/from agriculture, pollutant emissions and biomass production and consumption. European Union countries are witnessing a growing share of sphere I agribusiness (mainly including services, the fuel and energy sector and the chemical industry) in material input to agriculture. While this reflects production modernization efforts, it involves a greater environmental burden. EU countries are reporting a decline in direct material input and the domestic consumption of agricultural biomass per euro of GDP. These changes are indicative of less intensive use of environmental resources (dematerialization of the economy), which is consistent with the assumptions of sustainable development. To summarize, it may be concluded that countries at higher levels of agricultural development are meeting the environmental objectives of sustainable development to a greater extent than countries at lower levels of socioeconomic development.

INTRODUCTION

Freedom, part of human nature, is a basic category of fundamental importance to economics, politics and law [Tomczak 2010]. In turn, human freedom is the key message of the sustainable development concept which represents the next stage of research on agricultural and agribusiness development [Zegar 2012]. Today, sustainable development is defined as meeting present needs without compromising the ability of future generations to meet their own needs [Griggs et al. 2013]. The emergence of the sustainable development concept was driven by progress in socioeconomic development at a national level. Its main assumptions include ensuring durability and providing the greatest possible net

[1] The publication was created with the support of the National Science Centre under the project: "Input-output model for the agribusiness in selected countries around the world in a context of sustainable development". Project number 2018/29/B/HS4/02262 and the National Science Centre under the project: "The European Union's agriculture sector and its changes in relation to agribusiness theory". Projekt numer 2012/07/B/HS4/02837.

benefits from economic development while preserving the utility and quality of natural resources and keeping the consumption of goods and services at an environmentally acceptable level [Fiedor, Jończy 2009]. The literature indicates many separate aspects which need to be covered by sustainable development. This includes ecological, economic, social, psychological, demographic, territorial and intertemporal dimensions [Kiełczewski 2010]. Yet, no matter how many components of sustainable development can be identified, they extend over economic, social and environmental issues in a more or less disaggregated form [Sadowski 2012].

In the European Union's policy, too, measures are taken to establish sustainable consumption and production patterns. This is evidenced by many aspects, including growing environmental requirements for agriculture under the CAP. The decoupling of payments from production is expected to reduce the consumption of natural resources, improve the efficiency of their use and reduce harmful emissions into the air [Świerkula 2006]. This is especially important from the perspective of environmental protection because ca. 18% of anthropogenic greenhouse gas emissions around the world are related to animal farming and manure management [Garnett 2009]. In turn, food and beverage consumption accounts for 20–30% of diverse environmental impacts of total consumption in Europe [Aronsson et al. 2014]. As emphasized in another study, agricultural food production accounts for ca. 80% of global carbon emissions related to food production and 14%–24% of total global emissions [Notarnicola et al. 2012].

Previous analyses of agriculture and agribusiness were underpinned by a classical approach to this very sub-system of the national economy related to food production and distribution [including Mrówczyńska-Kamińska 2015]. The extended approach to agribusiness includes the classic concept of agribusiness, with the addition of products made in the non-food sphere [Piwowar 2014] and the environmental relationships of that sector. The reason for understanding agribusiness as depicted above is that in many countries around the world, it developed [in the classical sense] as a part of the economic industrialization process, and often involved environmental pollution and biodiversity degradation. So far, the development of agribusiness has been based on industrial innovation in the technical and technological area, leading to environmental issues and natural resource degradation [Zegar 2012]. From the perspective of the modern sustainability paradigm, it is highly important to maintain a balance between social development and the environmental situation. When analyzing economic processes, it is crucial to understand the biophysical and social context of production, trade and consumption processes. It is crucial to find the right way of economic development for a country [Piwowar 2014, Gowdy, Mesner 1998]. In view of the above, European Union countries decided to make sustainable development a topic of importance. The preparation of European environmental accounts was initiated in order to monitor sustainable economic development. In 1994, the Commission presented their first "green accounting" strategy. Since then, relevant accounting methods have been developed; as a result, as of 2014, EU member countries have regularly delivered the first sets of environmental-economic accounts. The most common components concern calculating physical atmospheric emissions (including greenhouse gas emissions), material intensity, amounts of money spent on environmental protection and taxes as well as environmental charges.

MATERIAL AND METHODS

Due to the growing importance of sustainable socioeconomic development at a national level, this paper makes an attempt to identify and assess the relationships between agriculture (as the main component of agribusiness) and the environment in European Union countries in light of input–output tables.

This is based on data retrieved from input-output tables from 2000 and 2014 and their satellite accounts (European environmental accounts). Input-output tables were used to determine the material input and output to/from agriculture of European Union countries and other spheres of agribusiness[2]. In turn, European environmental account data allowed to analyze the level of and changes in total greenhouse gas and pollutant emissions (ammonia, methane, nitrous oxide and carbon dioxide) to the environment per global production unit and per hectare of agricultural land. Also, direct input and the domestic consumption of biomass (as total figures and in relation to GDP) in 2000 and 2018 were identified. This enabled the assessment of progress in implementing sustainable development assumptions in the agriculture of countries covered by this analysis and a comparison of them.

RESULTS OF THE STUDY

MATERIAL INPUT AND OUTPUT TO/FROM AGRICULTURE BASED ON INPUT-OUTPUT TABLES

Figure 1 presents the mix of materials supplied to agriculture in European Union countries in 2014. An important component of (raw) materials supplied for use in agricultural production is self-supply, whereas the remaining part of intermediate consumption originates from the food industry and other sectors of the national economy. As a consequence of economic development, sectors which supply agriculture with productive input and services have a growing share in the production of agricultural raw materials [Tomczak 2005, Mundlak 2000]. In 2014, the key sectors supplying agriculture with productive input and services intended for basic production included the fuel and energy industry, the chemical industry as well as services and transport equipment. Combined together, they supplied (on average) 90% of all input delivered from the first sphere of agribusiness[3]. Input from the fuel and energy industry reflect the modernization of agricultural machinery and, thus, a higher energy consumption in farms. This is an important yardstick of agricultural development at the current level of technology used in this sector of the national economy. However, increased energy consumption involves the problem

[2] The analysis of input and output to/from agriculture extends over three spheres of agribusiness: sphere I constitutes industry sectors which deliver productive input and services to agriculture and food sectors; sphere II covers agriculture; sphere 3 represents the food sector [Davis, Goldberg 1957]. Input to agriculture includes all raw materials, products and services used in the production of agricultural raw materials. In turn, output from agriculture to other sectors of the national economy represents the flows of agricultural raw materials used in the production of goods other than food.

[3] Own calculations based on 2014 World Input-Output Tables for different European Union countries, accessed on April 20, 2018.

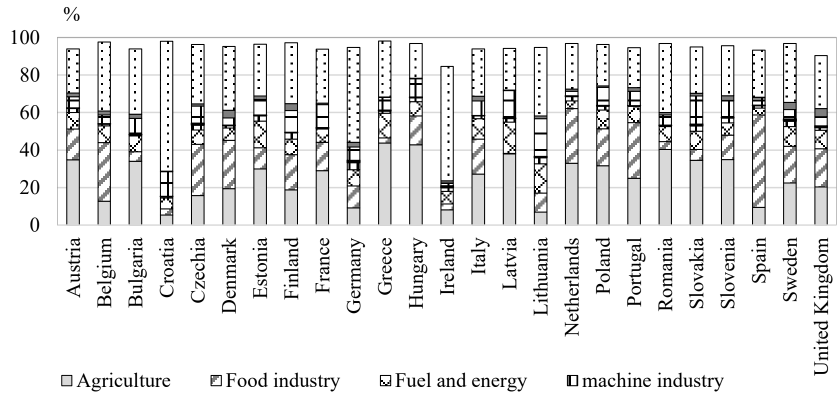

Figure 1. The structure of material inflow to agriculture from selected branches of the national economy in European Union countries in 2014

Source:own calculations based on [WIOD 2014]

of greenhouse gas (mainly carbon dioxide) emissions to the environment, which fails to promote sustainable development. The same is true for products of the chemical industry [mainly fertilizers and plant protection products] which are a significant component of the mix of materials supplied to agriculture in the countries considered (ca. 20% of all input to Lithuanian agriculture and from ca. 7 to 12% in other countries surveyed). Note, however, that the growing consumption of fertilizers and plant protection products in agriculture is one of the major sources of greenhouse gas emissions to the environment.

To summarize the changes in material input to agriculture, it should be noted that – from the perspective of the main concepts of sustainable development – increased input to agriculture from different sectors of the national economy comprising the first sphere of agribusiness can lead to an increase in adverse environmental impacts.

Based on input-output tables, an attempt can be made to determine the volume of material input to agriculture from other sectors of the national economy. In European Union countries, input from the agricultural sector are mostly supplied to the food sector which means that agricultural raw materials are primarily used to produce food. In 2014, over 90% of agricultural raw materials were delivered to the food industry or were traded internally in agriculture. Conversely, small quantities of agricultural raw materials are supplied to other sectors of the national economy. In 2014, in European Union countries, agricultural raw materials were also supplied to the chemical industry, the rubber and plastic products industry and the service sector. As regards the latter destination, agricultural raw materials were mostly delivered for wholesale and retail trading4. What matters, from the perspective of assessing sustainability, is the outflow of raw materials from agriculture to the fuel and energy industry (Figure 2). In most Community countries that share is very low, except for Dutch agriculture where agricultural raw materials worth EUR 450,000 were delivered to that industry in 2014 (2.3% of the total value of agricultural raw materials

4 Own calculations based on 2014 World Input–Output Tables for different European Union countries, accessed on April 20, 2018.

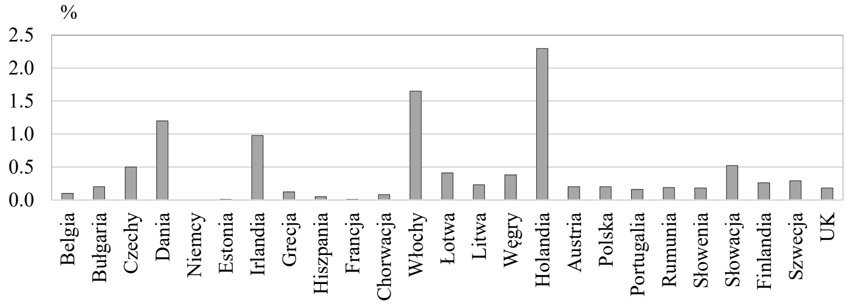

Figure 2. The share of material outflow from agriculture to the fuel and energy industry in the total value of indirect demand of this branch of the national economy in European Union countries in 2014

Source: own calculations based on [WIOD 2014]

delivered for further processing). Compared to other EU countries, Italy also reported an important contribution (1.7%) of agriculture to meeting the intermediate demand of the fuel and energy industry. In Denmark and Ireland, it was ca. 1.2%. Although the objective of the EU policy is to increase the share of biofuel components in fuels, agriculture in European Union countries, in the study period, did not deliver a considerable volume of agricultural raw materials for energy generation purposes. It certainly does not rule out the possibility that a greater part of agricultural raw materials will be delivered for these purposes in the future.

MATERIAL OUTPUT BASED ON ENVIRONMENTAL ACCOUNTS: EMISSION OF GREENHOUSE GASES AND ATMOSPHERIC POLLUTANTS[5]

The first major component of environmental accounts is to assess and publish data on greenhouse gas emissions and atmospheric pollution related to agriculture. In the European Union, in 2017, the emission of greenhouse gases and atmospheric pollutants of agricultural origin to the environment totaled nearly 103 million tons of carbon dioxide, 3.6 million tons of ammonia, 9.6 million tons of methane and 627.6 tons of nitrous oxide (Table 1). The figures for carbon dioxide were higher than in 2008 (by ca. 800 thousand tons),whereas the emission of other gases and pollutants was slightly smaller which evidences a reduction in the pollution intensity of European Union agriculture. The need for protecting the atmosphere in areas used for agriculture plays a major role among the various measures related to agriculture and the environment. Atmospheric pollutants generated in large quantities in the broadly defined agricultural production process include gaseous inorganic nitrogen compounds: ammonia and nitrous oxide, which contribute to the acidification and eutrophication of natural ecosystems. Also, nitrous oxide plays a considerable role in strengthening the greenhouse effect and accelerates ozone depletion [Marcinkowski 2010]. In the study period, ammonia emissions from agriculture followed a downward

[5] This part uses fragments of publications [Szuba-Barańska, Mrówczyńska-Kamińska 2016].

Table 1. Greenhouse gas emissions and air pollution to the environment from agriculture of European Union countries in 200720/08 and in 2016/2017

Specification	Greenhouse gas emissions and air pollution [thous. t]							
	ammonia		methane		nitrous oxide		carbon dioxide	
	2007	2016	2008	2017	2008	2017	2008	2017
EU-28	3,721.6	3,611.1	9,705.1	9,663.7	609.9	627.6	9 572.6	10,366.2
Belgium	65.2	63.4	233.8	233.5	13.9	13.7	161.7	176.9
Bulgaria	42.9	42.3	76.8	70.2	10.8	16.0	20.3	33.4
Czech Rep.	72.1	65.5	147.7	146.9	13.7	15.0	195.8	283.3
Denmark	78.3	70.8	223.6	221.8	16.5	16.4	231.2	219.1
Germany	586.3	629.2	1,324.4	1,327.4	98.9	101.2	2,482.6	2,924.0
Estonia	9.7	10.6	23.1	24.6	2.3	2.5	5.3	15.0
Ireland	106.1	115.5	473.0	518.7	19.2	21.0	293.0	367.8
Greece	62.3	51.4	196.3	177.9	12.8	11.3	28.6	34.1
Spain	456.8	448.8	993.1	987.7	40.7	47.7	345.3	611.1
France	585.9	591.4	1,606.2	1,541.8	122.7	119.9	1,773.3	1,943.2
Croatia	33.7	29.3	65.5	61.2	5.9	4.1	96.6	81.1
Italy	390.1	358.5	772.2	787.7	38.8	35.8	516.7	435.9
Latvia	12.6	13.9	34.8	38.8	5.3	6.0	5.9	33.9
Lithuania	34.5	30.2	79.7	71.1	7.4	8.7	30.0	30.4
Hungary	80.1	78.4	100.6	110.0	11.6	13.7	90.8	212.1
Netherlands	134.3	110.0	460.9	501.5	21.9	21.3	70.6	46.9
Austria	61.8	63.8	184.1	188.3	8.4	8.3	104.9	114.5
Poland	307.6	259.4	561.9	578.4	53.9	54.9	853.1	920.0
Portugal	47.6	45.7	179.1	183.2	7.6	7.6	55.2	53.9
Romania	177.6	147.1	595.8	508.7	19.7	21.5	137.0	124.6
Slovenia	17.8	16.6	47.6	47.5	1.6	1.6	19.7	19.3
Slovakia	31.9	29.0	47.0	43.4	4.1	4.7	48.1	71.2
Finland	30.9	28.1	99.4	102.1	12.5	12.6	326.6	198.5
Sweden	48.4	46.7	134.6	131.4	11.7	12.7	104.6	127.5
United Kingdom	233.9	253.0	1,012.6	1 027.4	46.5	47.9	1 571.9	1,280.6

Source: own elaborations based on Eurostat data trend in European Union countries, reaching 3.6 million tons in 2016. The German and French agricultural sectors are the largest contributors (with 629 and 591 thousand tons, respectively). Importantly, these countries witnessed an increase in ammonia emissions from agriculture, which should be regarded as an adverse development. The Spanish, Italian, Polish and British agricultural sectors also generate relatively large quantities of ammonia (450, 360 and ca. 250 thousand tons, respectively, in the last year surveyed). Conversely, Estonian and Latvian agriculture has the smallest share (ca. 10.0 thousand tons). The highest ammonia emissions per hectare of agricultural land were in the Netherlands (ca. 6.0 kg), Belgium (46 kg), Slovenia and Germany (34-37.0 kg). The lowest ratios were observed in Bulgaria (less than 9 kg) and Latvia (ca. 7.0 kg). In turn, the ratio between ammonia emissions from agriculture and the output value reached the highest levels in Slovenia, Slovakia, Croatia, Ireland, Germany, the Czech Republic and Baltic countries (0.013 t/EUR). The differences in levels of ammonia emissions from agriculture to the environment mostly depend on the importance of animal production in total agricultural production. In farms with a large share of livestock production, excrement of farmed animals is the main [though not the sole] source of nitrogen emissions in the form of ammonia, and is collected, stored and used primarily in the form of slurry [Marcinkowski 2010]. Ammonia emissions are also a consequence of using natural and mineral nitrogenous fertilizers [Marcinkowski 2010]. From the perspective of environmental care, it is important to reduce ammonia emissions from agriculture. This can be done through different methods, including the wide adoption and general use of liquid organic fertilizers applied to the soil (for instance, in Denmark and the Netherlands it enabled a considerable reduction in ammonia emissions to the environment) [Van Jaarsveld 2004].

Over the study period, emissions of nitrous oxide from European Union agriculture to the environment followed an upward trend, reaching 628 thousand tons in 2017. The greatest contributors were Germany and France, with a share of nearly 35.0% in total emissions of nitrous oxide from agriculture to the atmosphere. Quite large quantities are also emitted by British, Polish and Italian agriculture (ca. 50 and 36 thousand tons, respectively). In other countries, nitrous oxide emissions are low in absolute terms. Examining the emissions of nitrous oxide per inhabitant, similarly to ammoniac emissions, Irish, Danish and Latvian agricultures show the highest share of emissions As regards nitrous oxide emissions per hectare of agricultural land, the highest emissions of this gas were observed in Slovenian, Dutch, Belgian and Danish agriculture. As regards nitrous oxide emissions, the pollution intensity of production remains between 0.001 and 0.004 tons per EUR 1. An anthropogenic source of nitrous oxide is the release of ammonia [which almost entirely originates from agriculture] to the atmosphere. It is extremely important to further reduce nitrous oxide emissions because increased quantities of nitrous oxide in the atmosphere result in ozone depletion and accelerate climate change [Marcinkowski 2010].

Another chemical compound responsible for the greenhouse effect is carbon dioxide. It has the highest share in agricultural emissions of greenhouse gases to the environment. In 2017, carbon dioxide emissions from European Union agriculture totaled over 10.3 million tons (ca. 1.0 million tons more than in 2008). The largest quantities of carbon dioxide are emitted to the environment from German, British, French, Polish and Italian agriculture (75.0% of 2017 total emissions). As shown by the analysis of carbon dioxide emissions per hectare of agricultural land, the largest quantities are generated in Germany and Belgium (1,5-1,8 t/ha). In turn, the pollution intensity of production reached the highest levels in Germany and the Czech Republic (ca. 0.05 tons per EUR 1). Carbon dioxide emissions from agriculture to the atmosphere are driven by any and all measures that improve access to oxygen and lead to temperature rises. Processes such as plowing, mixing diverse kinds of biomass with casing soil and removing excess water are conducive to these developments and are a major source of carbon dioxide emissions to the atmosphere. Permanent grassland and forest land are a less efficient source of carbon dioxide and are a farming method that helps keep carbon in the soil. However, all agri-technical processes such as fertilization and liming result in increased carbon dioxide emissions [Sapek 2009]. Reducing the carbon content of soil due to gaseous emissions and leaching resulted in actions being taken to renew soil organic matter and improve the retention of organic carbon in the soil [carbon sequestration]. This term applies primarily to reducing the emission of greenhouse gases to the atmosphere, and also refers to soil processes that reduce carbon emissions and losses [Sapek 2009, after Lal 2000]. Therefore, environmental protection requires that monocultures be avoided as they result in the destruction of soil structure and excessive soil aeration, the ultimate consequence of which is the release of carbon dioxide to the atmosphere [Krasowicz et al. 2011]. Another method for reducing carbon emissions from agriculture is using renewable energy for heating purposes, reducing heat losses in buildings by using adequate ventilation and reducing fuel consumption. However, from the perspective of progressing agricultural mechanization processes, this seems very difficult to achieve [Duer et al. 2004].

If there is not enough oxygen in the soil, a chemical reaction takes place that reduces organic carbon compounds and releases methane as the gaseous product. It is the basic greenhouse gas, even more active than carbon dioxide. Methane remains in the atmosphere for approximately 12 years only (compared to 50-200 years for carbon dioxide). Therefore, methane emissions are of major importance to the environment on a worldwide basis

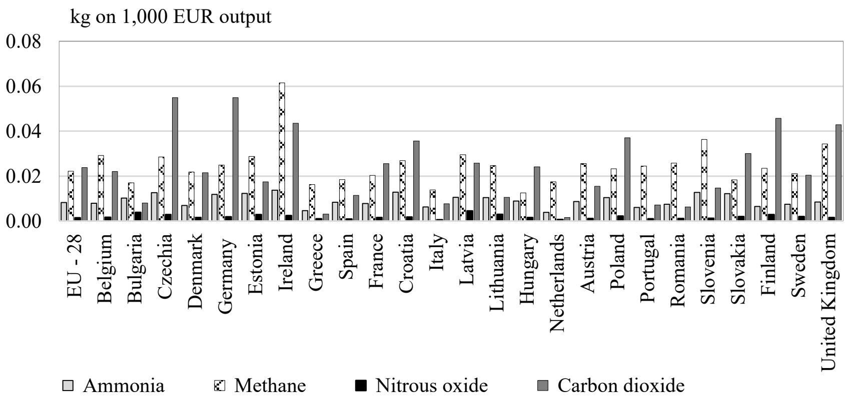

Figure 3. Greenhouse gas emissions and air pollution to the environment from the agriculture of European Union countries in 2017

Source: own elaboration based on Eurostat data www. ec.europa.eu, accessed 20.06.2019

[Sapek 2009, after Lal 2000]. Methane (also referred to as marsh gas) is released by swamps, alluvial soils and wetlands. Its agricultural sources are enteric fermentation processes and animal excrements. The quantities of methane generated in digestive processes depend on the numbers of ruminants and the type and mass of fodder fed to animals. In turn, the volume of methane emissions from excrements primarily depends on how excrement is stored; this is related to temperature and oxygen ingress because methane is abundantly liberated under anaerobic conditions [Mielcarek 2012, Karłowski et al. 2002, Kolasa-Więcek 2011]. Over the study period, methane emissions to the environment from EU agriculture decreased from 9.7 million tons in 2008 to ca. 9.6 million tons in 2017. However, no significant changes at a country level were observed in that period. The greatest amounts of methane are released by French agriculture (ca. 1.5 million tons per year), followed by German (1.3 million tons) and British (1.0 million tons) agriculture.

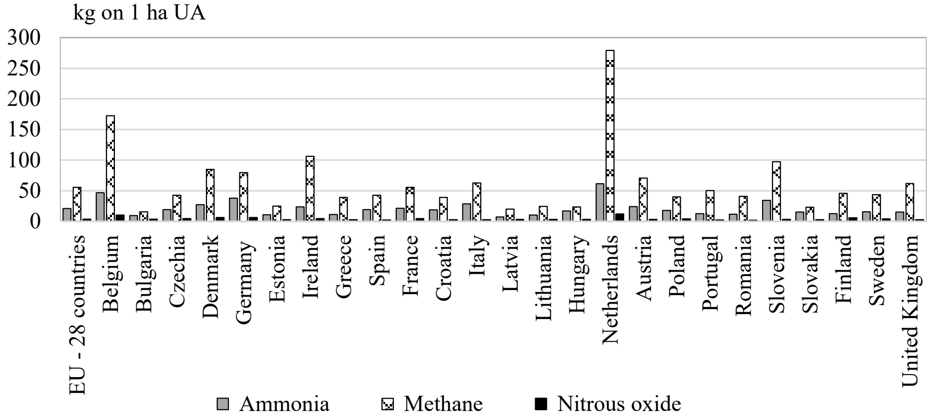

Figure 4. Greenhouse gas emissions and air pollution to the environment from the agriculture of European Union countries in 2017

Source: own elaborations based on Eurostat data www. ec.europa.eu, access date 20.06.2019

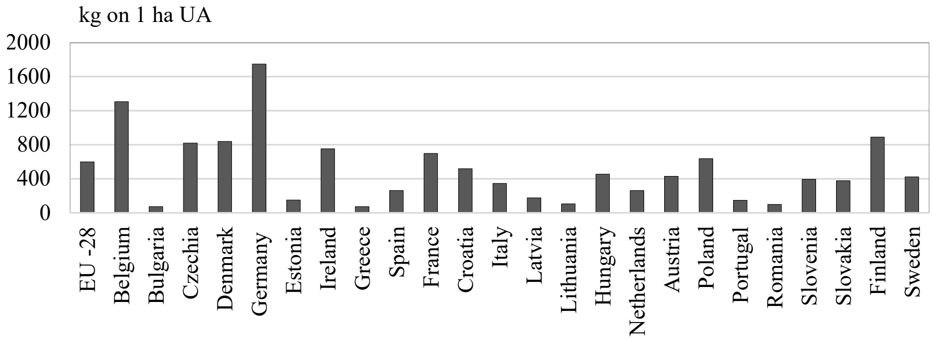

Figure 5. Carbon dioxide emissions from the agriculture of European Union countries in 2017

Source: own elaboration based on Eurostat data www. ec.europa.eu, access date 20.06.2019

In other countries, methane emissions were much below 1 million tons per year. Methane emissions are high in locations where livestock production prevails. The highest emission per hectare of agricultural land level being recorded in in the Netherlands (ca. 180.0 kg/ha), Belgium (170.0 kg/ha) and in Ireland and Slovenia (ca. 100.0 kg/ha). As regards methane, the greatest pollution intensity of agricultural production was noted in Ireland and Slovenia (0.06-0.04 tons/EUR). Methane has a much greater potential as a greenhouse gas than carbon dioxide, and therefore its emissions must be reduced. In agriculture, methane is mainly produced by enteric fermentation in animals and during the storage and use of manure and slurry. Therefore, efficient ways of reducing methane emissions to the atmosphere include the adequate management of these products. An appropriate selection of nutrients in feeding stuff and the production of energy crops on agricultural land also have a beneficial impact on reducing methane emissions to the atmosphere. The greatest potential for the reduction of methane emissions to the environment lies in animal excrement treatment and using agricultural biomass in biogas plants [Bartkowiak 2010].

Another attempt to assess the degree of agricultural sustainability can consist of analyzing the amount of biomass generated in agriculture and used in the economy. To do so, this paper uses the Direct Material Input (DMI) ratio for the biomass of mostly agricultural origin and the Domestic Material Consumption (DMC) ratio (Figures 6 and 7). In order to determine the material intensity of the economy, these figures were compared against the GDP of different European Union countries. This resulted in the calculation of the intensity of environmental exploitation expressed as the quantity of materials used per production unit.

Most European countries recorded an increase in the production volume (2 billion tons in 2018) and consumption of biomass (1.8 billion tons in 2018) in agriculture. In all countries covered by this study, domestic biomass production was greater than biomass consumption, which is a positive development. The European Union, as a whole, is witnessing a decrease in the intensity of using natural resources in agriculture. The conclusion from the analysis of changes in the intensity of using natural resources in European Union economies is that both the production and consumption of biomass of agriculture per EUR 1 of GDP follow a downward trend. This evidences the dematerialization of economies which is a desired path of evolution from the perspective of environmental protection efforts.

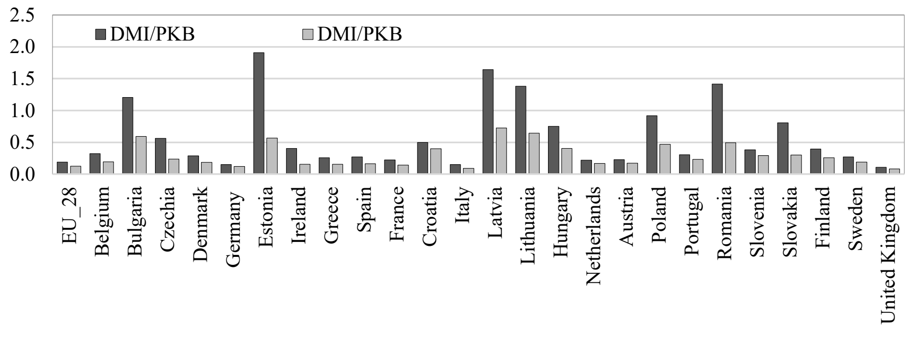

Figure 6. Direct material input (DMI) of biomass from the agriculture of European Union countries in 2000 and 2018

Source: own elaboration based on Eurostat data www. ec.europa.eu, access date 20.06.2019

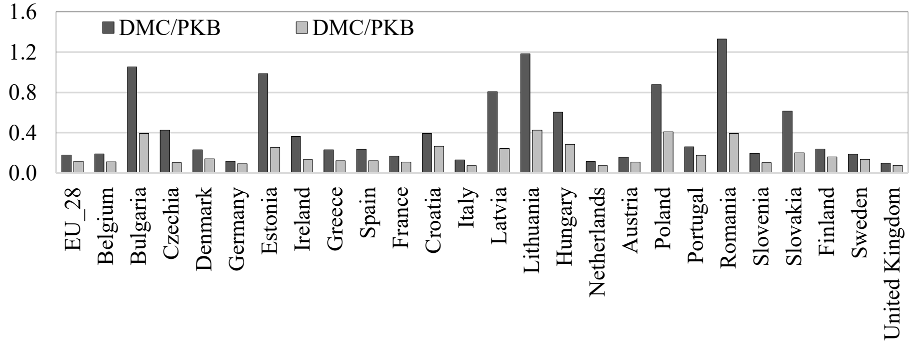

Figure 7. Direct material consumption (DMC) of biomass from the agriculture of European Union countries in 2000 and 2018

Source: own elaboration based on Eurostat data www. ec.europa.eu, access date 20.06.2019

SUMMARY

On the basis of this study, it was found that between the years 2008-2017, the emission of harmful compounds to the atmosphere from the agricultural sectors of European Union countries per EUR 1,000 of output production decreased. A similar trend was observed regarding the emission of pollutants per hectare of agricultural land. The changes in the production and use levels of biomass are faster in countries at lower levels of socioeconomic development than in highly developed countries. This is because Western Europe has a longer history of fighting for sustainability and has completed the relevant transformation processes to a certain degree. In countries that joined the European Community after 2004, the agricultural sector has just started to embark on a path towards sustainable development, and the changes in caring for the environment there are more rapid.

An initial attempt was made to use input–output tables to assess the sustainability of agricultural sectors in European Union countries, and it was proved that I/O tables can be useful for that purpose. The input to agriculture, as presented above, revealed that agriculture strongly depends upon other sectors of the national economy (including the fuel and energy industry as well as the chemical industry). On the other hand, agricultural raw materials continue to be used to a small extent in the manufacturing of products other than food. Another tool, which proved to be useful in assessing the sustainability of agricultural development, is data from European environmental accounts, i.e. satellite accounts to national accounts which, in turn, form the foundation for the establishment of input-output tables. As shown by the calculation of emission levels of greenhouse gases and pollutants to the environment, environmental impacts follow a downward trend, which is indicative of economic dematerialization. Also, there is a difference in pace between economic growth, use of natural resources and environmental degradation; resource productivity [efficiency] is increasing. To summarize, it may be concluded that countries at higher levels of agricultural development meet the environmental objectives of sustainable development to a greater extent than countries at lower levels of socioeconomic development.

Another final conclusion is that, due to a lack of data, the problem considered could only be presented to a limited extent. However, as demonstrated by analyses, data from input–output tables can be very useful in explaining new developments and processes related to the sustainable development concept taking place in agriculture.

BIBLIOGRAPHY

Aronsson Anna, Birgit Landquist, Aintzane Esturo, Gudrun Olafsdottir et al. 2014. *The applicability of LCA to evaluate the key environmental challenges in food supply chains.* [In] Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food SectorPages, Schenck Rita, Huizenga Douglas (ed.), 8-10. LCA Food, 8-10 October 2014, USA, San Francisco.

Bartkowiak Anna. 2010. *Opracowanie sektorowego planu działań określającego obszary współpracy w ramach partnerstwa „Methane to Markets" w zakresie zmniejszenia metanu z rolnictwa* (Development of a sectoral action plan defining the areas of cooperation under the Methane to Markets partnership in the field of reducing methane from agriculture). Poznań: Wydawnictwo IT-P.

Davis John, Ray Goldberg. 1957. *A concept of agribusiness.* Boston: Harvard University.

Duer Irena, Fotyma Mariusz, Madej Andrzej (ed.). 2004. *Kodeks dobrej praktyki rolniczej* (Code of Good Agricultural Practice). Warszawa: Fundacja Programów Pomocy dla Rolnictwa.

Fiedor Bogusław, Romuald Jończy. 2009. Globalne problemy interpretacji i wdrażania koncepcji sustainable development. [W] *Rozwój zrównoważony. Teoria i praktyka ze szczególnym uwzględnieniem obszarów wiejskich* (Global problems of interpretation and implementation of the concept of sustainable development. [In] Sustainable development. Theory and practice with particular emphasis on rural areas), eds. B. Fiedor, R. Jończy, 37-53. Wrocław: Uniwersytet Ekonomiczny we Wrocławiu.

Garnett Tara. 2009. Livestock-related greenhouse gas emissions: impacts and options for policy makers. *Environmental Science & Policy* 12 (4): 491-503.

Gowdy John, Susan Mesner. 1998. The evolution of Goorgescu-Roegen's bioeconomics. Review of Social Economy 56 (2): 136-156.

Griggs David, Mark Stafford-Smith, Owen Gaffney et al. 2013. Policy: Sustainable development goals for people and planet. *Nature* 495 (7441): 305-307.

Karłowski Jerzy et al. 2002. *Szczegółowe badania emisji metanu i podtlenku azotu z fermentacji jelitowej oraz odchodów zwierzęcych* (Detailed tests of methane and nitrous oxide emissions from intestinal fermentation and animal faeces). [In] VIII International Scientific Conference, 24-25 November, 2002, Warszawa.

Kiełczewski Dariusz. 2010. Istota i aksjologia zrównoważonego rozwoju. [W] *Ekonomia – polityka – etyka. Tom 3* (The essence and axiology of sustainable development. [In] Economics – politics – ethics, Vol. 3). Białystok: Wydawnictwo Uniwersytetu w Białymstoku.

Kolasa-Więcek Alicja. 2011. Prognozowanie wielkości emisji CH_4 z fermentacji jelitowej oraz hodowli zwierząt gospodarskich z wykorzystaniem sztucznej sieci neuronowej flexible byesian models (Forecasting of CH_4 emissions from enteric fermentation and livestock farming using an artificial neural network fl exible byesian models). *Journal of Research and Applications in Agricultural Engineering* 56 (2): 90-93.

Krasowicz Stanisław, Wiesław Oleszek, Józef Horabik, Ryszard Dębicki, Janusz Jankowiak, Tomasz Stuczyński, Jan Jadczyszyn. 2011. Racjonalne gospodarowanie środowiskiem glebowym Polski (Rational management of the Polish soil environment). *Polish Journal of Agronomy* 7: 43-58.

Marcinkowski Tadeusz. 2010. Emisja gazowych związków azotu z rolnictwa (Emission of nitrogen gas compounds from agriculture). *Woda – Środowisko – Obszary Wiejskie* 10 (3): 175-189.

Mundlak Yair. 2000. *Agriculture and economic growth. Theory and measurement.* Cambridge: Harvard University Press.

Mielcarek Piotr. 2012. Weryfikacja wartości współczynników emisji amoniaku i gazów cieplarnianych z produkcji zwierzęcej (Verification of the value of ammonia and greenhouse gas emission factors from animal production). *Inżynieria Rolnicza* 4 (1): 267-276.

Mrówczyńska-Kamińska Aldona. 2015. *Gospodarka żywnościowa w krajach Unii Europejskiej. Kierunki rozwoju, przepływy i współzależności* (Food economy in European Union countries, Directions of development, flows and interdependencies). Poznań: Wydawnictwo UP w Poznaniu.

Notarnicola Bruno, Giuseppe Tassielli, Pietro A. Renzulli. 2012. Modeling the agri-food industry with life cycle assessment. [In] *Life cycle assessment handbook: a guide for environmentally sustainable products*, ed. Mary Curran, 159-183. USA: Scrivener Publishing LLC.

Piwowar Arkadiusz. 2014. Biobiznes i jego elementy. [W] *Agrobiznes i biobiznes. Teoria i praktyka* (Biobusiness and its elements. [In] Agribusiness and biobusiness. Theory and practice), ed. S. Urban, 242-258. Wrocław: Wydawnictwo UE.

Sadowski Arkadiusz. 2012. *Zrównoważony rozwój gospodarstw rolnych z uwzględnieniem wpływu Wspólnej Polityki Rolnej* (Sustainable development of agricultural holdings, including the impact of the Common Agricultural Policy). Poznań: Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu.

Sapek Barbara. 2009. Zapobieganie stratom i sekwestracja węgla organicznego w glebach łąkowych (Loss prevention and organic carbon sequestration in meadow soils). *Inżynieria Ekologiczna* 21: 48-61.

Szuba-Barańska Ewelina, Aldona Mrówczyńska-Kamińska. 2016. An attempt to assess the impact of agriculture on the environment in the countries of Central-Eastern Europe. *Journal of Agribusiness and Rural Development* 3 (41): 401-412. DOI: 10.17306/JARD.2016.68.

Świerkula Elżbieta. 2006. *Ocena możliwości obliczania wskaźników przepływów materiałowych w oparciu o istniejące dane krajowe wg wypracowanych metodyk Europejskiej Agencji Środowiska (EAŚ) i organizacji współpracy gospodarczej i rozwoju (OECD)* (Assessment of the possibility of calculating material flow indices based on existing national data according to developed methodologies of the European Environment Agency (EEA) and organization of economic cooperation and development (OECD). Warszawa: Instytut na Rzecz Ekorozwoju.

Tomczak Franciszek. 2005. *Gospodarka rodzinna w rolnictwie. Uwarunkowania i mechanizmy rozwoju* (Family economy in agriculture. Conditions and development mechanisms). Warszawa: IRWiR PAN.

Tomczak Franiczek. 2010. Rozwój nauk ekonomicznych. Ujęcie historyczne i współczesność. Głos w dyskusji (Development of economic sciences. Historical approach and the present day. A voice in discussion). *Roczniki Nauk Rolniczych. Seria G* 97 (2): 84-89.

Van Jaarsveld John. 2004. *The operational priority substance model: description and validation of OPS-pro 4.1. RIVM Report no. 5000045001.2004.* Bilthoven: RIVM, National Institute of Public Health and Environmental, www.pbl.nl, access: 20.08.2014.

WIOD (World Input-Output Database). 2014. *Global input-output tables for European Union countries for 2014*, www.wiod.org, access: 24.04.2019.

Zegar Józef Stanisław. 2012. *Współczesne wyzwania rolnictwa* (Contemporary challenges of agriculture. Warszawa: PWN.

***

ROLNICTWO A ŚRODOWISKO W KRAJACH UNII EUROPEJSKIEJ W ŚWIETLE PRZEPŁYWÓW MIĘDZYGAŁĘZIOWYCH

Słowa kluczowe: zrównoważony rozwój, rolnictwo, przepływy międzygałęziowe, zanieczyszczenia powietrza, biomasa

ABSTRAKT

Celem artykułu jest próba zidentyfikowania i oceny relacji pomiędzy rolnictwem a środowiskiem w krajach Unii Europejskiej w świetle bilansów przepływów międzygałęziowych, w związku z rosnącą rolą zrównoważonego rozwoju społeczno-ekonomicznego państw. Do realizacji celu wykorzystano dane z bilansów przepływów międzygałęziowych oraz Europejskich Rachunków Środowiska. Przeanalizowano przepływy materiałowe z i do rolnictwa, emisję zanieczyszczeń oraz produkcję i konsumpcję biomasy. W napływach materiałowych do rolnictwa państw Unii Europejskiej wzrasta udział sfery I agrobiznesu, a w tym głównie usług oraz przemysłu paliwowo-energetycznego i chemicznego. Wskazuje to na unowocześnienie produkcji, jednak wiąże się z większym obciążeniem środowiska naturalnego. W krajach UE odnotowano zmniejszenie bezpośrednich nakładów materiałowych i krajowej konsumpcji biomasy z rolnictwa w przeliczeniu na 1 euro PKB. Zmiany te wskazują na zmniejszenie intensywności korzystania z zasobów środowiska (odmaterializowanie gospodarki), co jest zgodne z założeniami zrównoważonego rozwoju. Można stwierdzić, że w państwach, w których rolnictwo jest lepiej rozwinięte realizacja prośrodowiskowych celów zrównoważonego rozwoju odbywa się w większym stopniu niż w krajach o niższym poziomie rozwoju społeczno-gospodarczego.

AUTHOR

ALDONA MRÓWCZYŃSKA-KAMIŃSKA PROF. PULS, DR HAB.
ORCID: 0000-0001-5439-7339
Poznań University of Life Sciences
Department of Finance and Accounting
28 Wojska Polskiego St., 60-637 Poznań, Poland