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AN ATTEMPT TO ASSESS THE IMPACT OF AGRICULTURE ON THE ENVIRONMENT IN THE COUNTRIES OF CENTRAL-EASTERN EUROPE

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Abstract. The main aim of the study was to identify and evaluate the progress of implementation of selected assumptions on sustainability of agriculture in countries of Central-Eastern Europe in relation to environmental protection. Data from the input-output balance sheets and the European Environmental Accounts were used to realize the aim of the study. The analysis considered material flows to and from agriculture, pollution, and the production and consumption of biomass. The share of the participation of agribusiness sphere I, including mainly services, as well as the fuel, energy and chemical industries, has been increasing in the material inflows to agriculture in the countries of Central-Eastern Europe. This indicates production modernization, associated with a higher load on the environment. The highest emissions of greenhouse gases and air pollutants into the environment per 1,000 euro GDP were recorded in Lithuania, Romania and Latvia. The Czech Republic, Slovenia and Slovakia have the lowest values of emissions. In Latvia, there was no overall reduction in pollution emitted by agriculture in 2008–2012. Emission of these pollutants per 1,000 euro GDP and 1 ha UAA (utilized agricultural area) of agricultural land decreased in most countries in the analysis. In EU countries of Central-Eastern Europe, a reduction in direct material input and domestic consumption of biomass from agriculture per one euro of GDP is reported. These changes indicate a decrease in the intensity of use of natural resources (dematerialising economy), which is consistent with the objectives of sustainable development. In countries where agriculture is better developed, the implementation of pro-environmental goals of sustainable development takes place to a greater extent than in countries with lower levels of socio-economic development.

Key words: sustainable development, agriculture, air pollution, biomass

INTRODUCTION

The idea of sustainable development was born with the progressive socio-economic development of countries. The main assumptions were stability and assurance for the largest net benefits of economic development while preserving the usefulness and quality of natural resources and consumption of goods and services on acceptable levels in an environmental point of view (Fiedor and Jończy, 2009). There are a lot of separate aspects which sustainable development should be concerned about (Kiełczewski, 2010). For example the environmental, economic, social, psychological, demographic and spatial aspect. On the other hand, Pawłowski (2006) points to the moral, ecological, economic, legal, social and political plane of sustainable development, regardless of the number of distinctive elements of sustainable development that includes more or less disaggregated economic, social and environmental issues (Sadowski, 2012).

Efforts to preserve the balance between the environment and socio-economic development also apply to agriculture. Changes in food production and agriculture are the result of advancing processes of economic development, science and globalization. Environmental aspects

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also play an increasing role. Efforts to create sustainable patterns of consumption and production are also present in the policy of the European Union (EU). Among others, the main evidence is initiation of environmentally-friendly growing requirements of agriculture under the Common Agricultural Policy (CAP). Implementation of the principles of decoupling should result in reduction of the natural resources use, improving the efficiency of their use and reducing harmful emissions and waste into the atmosphere (Świerkula, 2006). It's important from the point of view of environmental protection because about 18% of global anthropogenic emissions of greenhouse gases are associated with animal husbandry and fertilizers economy (Garnett, 2009).

AIM AND METHODS

Concerning the increasing role of sustainable socio-economic development of countries mentioned in the article, the authors attempted to identify and assess the progress of implementation of selected assumptions sustainability of agriculture countries of Central-Eastern Europe in relation to the aspects related to environmental protection.

Data input-output balance sheets for 2010, as well as satellite accounts to them (European Environmental Accounts), were used to achieve the aim of the study. Based on the input-output balance sheets the value and structure of input and output material to/from the agricultural countries of Central-Eastern Europe from other spheres of agribusiness were determined[1]. Data from the European Environmental Accounts allowed to perform analysis of the level and changes in greenhouse gas emissions and pollution to the environment in general (ammonia, methane, nitrous oxide and carbon dioxide) per 1000 euro Gross Domestic Product (GDP) and per 1 ha Utilized Agricultural Area (UAA) in 2008 and 2012 and to determine the direct investment and domestic consumption of biomass in general and in relation to GDP between 2004 and 2013. This enabled the assessment of the implementation of proenvironment principles of sustainable development in agriculture of the countries covered by the analysis and enabled the mutual comparison of the countries.

[1] Analysis of input and output to/from agriculture includes three spheres of agribusiness: industries producing means of production and services for agriculture and the food industry (sphere I), agriculture (sphere II) and food industry (sphere III) (Davis and Goldberg, 1957). Input to agriculture include all raw materials, products and services used for the production of agricultural raw materials. Output from agriculture to other sectors of the national economy include the input of agricultural raw materials for the production of non-food products.

RESULTS

Input and output of material to/from agriculture on the basis of the input-output balance sheets

The classic concept of the food economy points to the basic relationships between the various spheres of industry and other sectors of the national economy. In the context of examining the sustainability of the agri-food sector it seems important to analyse the situation in terms of material flows. As for the material flows they will be analysed as the interdependence of agriculture with other branches of the national economy. Intermodal flows in agriculture allow to specify the participation and the importance of individual branches of the national economy in the production of agricultural raw materials. It is important from the point of view of sustainability research in the agricultural sector in the context of economic and social to research, their structure and changes over time. Increased input (intermediate consumption) for agriculture from different branches of the national economy suggest an increasing dependence of food production from a specific raw material, which may indicate lack of sustainability. From the point of view of the analysis, a special attention should be paid to the first sphere of agribusiness, because the forces which boost the production of agricultural raw materials and food products derived primarily from the outside, and are the products of the industry and all kinds of services. Through the study of flows from sphere I to agriculture there is a possibility to assess the progress in the sector's sustainable development. On the one hand, agriculture provides availability to the growing mass of raw materials, but on the other hand, however, reports an increasing demand for resources of production of industrial origin and all kinds of services. In the process of the integration of agriculture with industry an increasing role is played by the supply that covers all resources of production and services (Woś and Zegar, 1983). Developed industry strongly supports and modernizes agriculture, turning it into a kind of industry branch. It can also activate its development, as well as the development of

the entire agri-food sector. However, a high demand for industrial resources of production is not conducive to the sustainable development of the agricultural sector. Such a high consumption of fertilizers and plant protection products, may cause too high emission of gases and pollutants into the environment.

Table 1 shows the size and structure of the material supply of agriculture in the countries of Central-Eastern Europe in 2010. The supply of materials (raw materials) from agricultural production is an important item of subsistence. The remaining part of intermediate consumption goes from the first and third spheres. As a result of economic development in the production of agricultural raw materials, the share of agriculture increases in the sectors that supply the resources of production and services (Tomczak, 2005; Mundlak, 2000). In 2010, the share of the first sphere in the supply of agricultural materials in the countries of Central-Eastern Europe remained at a level of about 70% in Lithuania to about 40% in Romania and Bulgaria. It is believed that the increase in the value of shares and the supply of material from sphere I of agriculture and agribusiness is due to the acquisition of the agricultural sector of these countries funds under the CAP. The increase in income, caused partly by transfers to agriculture has enabled a shift from self-supply for the purchase of industrial resources of production. Among the most important sectors that provide the resources of production in agriculture and services for primary production are industry of fuel and energy, chemical industry, services and industries of transport, which together in 2010 affected agriculture on average 90% of all funds came from sphere I of agribusiness[2]. Flows from fuel and energy industry suggest the modernization of machinery in agriculture and thus higher energy consumption in households, which is an important measure for reducing the development of agriculture at the current level of technology used in this sector of the national economy. However, increased energy consumption is related to the problem of environmental emissions of greenhouse gases, mainly carbon dioxide, which is not conducive to sustainable development. Likewise the products of the chemical industry (mainly fertilizers and pesticides). The industry's products take an important position in the supply of agricultural materials in the countries concerned (about 30.0% of all inflows into Lithuanian agriculture to about 7% to 12% in the other analysed countries). It needs to be highlighted, that the increasing use of fertilizers and pesticides in agriculture is one of the major sources of greenhouse gas emissions into the environment (which will be discussed later in the article).

Summarizing the changes in input materials for agriculture it should be noted that from the point of view of labour productivity growth and the supply of modern resources of production in the agricultural sector, the share of the first sphere in the supply of agriculture should grow. According to economic development theories it is a determinant of positive structural changes and the level of modernity in the whole national economy. But from the point of view of the main concepts of sustainable development increasing flow of individual branches of the national economy of the first agribusiness agriculture sphere may increase the negative impact on the environment.

Based on the input-output balance sheets, it is possible to determine the amount of material outflows from agriculture to other branches of the national economy. In the countries of Central-Eastern Europe, the agricultural sector supplies mainly agri-food sectors, which means that raw materials from this sector, are mainly used for food production[3]. In 2010 more than 90% of the agricultural raw materials reached either in the food industry, or were used as domestic trade in agriculture. On the other hand, in other sectors of the national economy the national supply of agricultural raw materials is low. In the countries of Central-Eastern Europe in 2010, agricultural commodities were transferred yet to the chemical rubber and plastics industry and services. Within the services of agricultural raw materials found their place primarily in the wholesale and retail trade[4]. From the point of view of the sustainability research, it should be noted that an outflow of resources from agriculture to fuel and energy industry practically equalls to zero in the countries in focus. Although the policy of the EU is moving towards increasing the share of bio fuels, the agriculture in the countries of Central-Eastern Europe in the investigated period did not transfer agricultural raw

[2] Own calculations presented in Table 1.

[3] Because of the small differences in the structure of the material output from agriculture to the various branches of national economies of countries included in the research does not provide details data of the described values.

[4] Own calculations based on input-output balance sheets of the Central-Eastern Europe countries in 2010.

Table 1. Input-output in agriculture of the Central-Eastern Europe countries in 2010
Tabela 1. Przepływy materiałowe do rolnictwa w krajach Europy Środkowo-Wschodniej w 2010 roku

Specification Wyszczególnienie	Bulgaria Bułgaria		Czech Republic Czechy		Estonia		Lithuania Litwa		Latvia Łotwa		Poland Polska		Romania Rumunia		Slovakia Słowacja		Slovenia Słowenia		Hungary Węgry	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
From I sphere Z I sfery	1 137	41.6	2047	55.9	189	50.1	1 044	69.3	134	35.1	5 601	43.1	2 810	37.5	831	58.5	299	42.9	1918	45.7
Industry fuel and energy Przemysł paliwowo--energetyczny	231	8.5	276	7.5	49	13	70	4.6	18	4.7	1 913	14.7	633	8.4	178	12.5	41	8.2	420	10
Industry metalurgical Przemysł metalurgiczny	28	1	14	0.4	4	1.2	4	0.2	1	0.3	232	1.8	72	1	9	0.6	3	0.2	17	0.4
Industry electromechanical Przemysł elektromaszynowy	12	0.4	10	0.3	1	0.4	11	0.7	.	x	60	0.5	21	0.3	4	0.3	4	0.2	11	0.3
Industry means of transport Przemysł środków transportu	34	1.3	92	2.5	14	3.6	44	2.9	10	2.6	407	3.1	15	0.2	27	1.9	9	3.7	85	2
Industry chemical Przemysł chemiczny	306	11.2	406	11.1	36	9.6	426	28.3	35	9.2	1 634	12.6	540	7.2	166	11.7	77	7.4	512	12.2
Industry building materials Przemysł mat. budowlanych	19	0.7	12	0.3	1	0.4	7	0.5	1	0.3	188	1.4	14	0.2	21	1.5	0	0.2	18	0.4

Table 1 cont. – Tabela 1 cd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Other industry Pozostałe gałęzie przemysłu	50	1.8	58	1.6	5	1.2	40	2.7	5	1.3	79	0.6	62	0.8	31	2.2	2	2	81	1.9
Services Usługi	366	13.4	482	13.2	29	7.7	167	11.1	14	3.7	740	5.7	462	6.2	125	8.8	78	6.5	290	6.9
Trade Handel	1	0	534	14.6	34	8.9	152	10.1	37	9.7	12	0.1	740	9.9	203	14.3	61	11.9	338	8.1
Constructions Budownictwo	35	1.3	49	1.3	6	1.7	9	0.6	1	0.3	65	0.5	68	0.9	31	2.2	20	2.2	6	0.1
Transport and communication Transport i łączność	49	1.8	113	3.1	10	2.5	105	7	9	2.4	255	2	173	2.3	30	2.1	6	0.5	135	3.2
Foresty Leśnictwo	7	0.3	1	0	0	0	10	0.7	1	0.3	14	0.1	11	0.1	7	0.5	0	0	4	0.1
Other branches Pozostałe gałęzie	0	0	0	0	0	0	0	0	1	0.3	1	0	0	0	0	0	0	0	1	0
From II sphere Z II sfery	1 233	45.1	481	13.2	133	35.1	245	16.3	219	57.3	4 340	33.4	4 504	60.1	497	35	217	48.1	1 654	39.4
From III sphere Z III sfery	365	13.3	1 130	30.9	56	14.8	218	14.4	29	7.6	3 067	23.6	185	2.5	93	6.5	120	8.9	625	14.9
Total Razem	2 735	100	3 659	100	378	100	1 507	100	382	100	13 008	100	7 500	100	1 421	100	636	100	4 197	100

Legend: a – million euro; b – %
Legenda: a – mln euro; b – %
Source: own elaboration based on input-output balance sheets.
Źródło: opracowanie własne na podstawie bilansów przepływów międzygałęziowych.

materials for energy purposes. This does not meane, of course, that in the future such a phenomenon will take place.

Output of material on the basis of the environmental accounts – emission of greenhouse gases and air pollution

Greenhouse gas emissions and air pollution to the environment from agricultural sources in 2012 in the EU amounted to nearly 93.2 million tons of carbon dioxide, 3.4 million tons of ammonia, 9.4 million tons of methane and 855 thousand tons of nitrous oxide (Table 2). The values were smaller than in 2008, what indicates the reduction pollution from in agriculture Union. Among the countries of Central-Eastern Europe the highest emissions of pollutants were noticed in Poland and Romania. In 2012 for the agriculture of the above economies, emission of ammonia amounted respectively to 257.3 thousand tons and 140.8 thousand tons; methane 597.8 thousand tons and 482.5 thousand tons; nitrous oxide 82.1 thousand tons and 30.6 thousand tons of carbon dioxide and 15.7 million tons and 1.3 million tons. The countries characterized by high emission were both Hungary, Czech Republic and Bulgaria. In those countries in comparison to 2008, emission of greenhouse gases and air pollutants derived from agriculture were lower (the exception is Romania, in which increased emission of carbon dioxide was reported). The countries of Central-Eastern Europe with the lowest level of emissions of greenhouse gases and air pollutants emitted into the environment from agriculture were Latvia, Slovenia and Estonia. At the same time Latvia was the only country in which there was no reduction in the emission of any of the contaminants during the analysed period.

Due to the different sizes of the economies of the countries included in the study to assess the level and changes in the emission of pollutants from agricultural sources into the atmosphere it is more methodical to use a comparison converting per 1 ha and 1000 euro of GDP.

One of the main gases emitted into the atmosphere by agriculture is ammonia. Its secretion is primarily associated with animal production. This gas escapes from

Table 2. Greenhouse gas emissions and air pollution to the environment from agricultural of the Central-Eastern Europe countries in 2008 and 2012 (thous. tonnes)
Tabela 2. Emisja gazów cieplarnianych i zanieczyszczeń powietrza do środowiska z rolnictwa państw Europy Środkowo-Wschodniej w latach 2008 i 2012 (tys. ton)

Specification Wyszczególnienie	Ammonia Amoniak		Methane Metan		Nitrous oxide Podtlenek azotu		Carbon dioxide Dwutlenek węgla	
	2008	2012	2008	2012	2008	2012	2008	2012
EU (28 countries) – UE (28 krajów)	3 530.4	3 394.2	9 830.6	9 440.5	895.4	855.3	96 223.7	93 194.5
Bulgaria – Bułgaria	29.0	21.3	60.2	56.0	8.7	9.5	1 167.2	1 076.1
Czech Republic – Czechy	64.7	53.8	127.3	119.0	19.5	18.0	1 188.9	1 119.7
Estonia	10.2	10.1	21.3	22.4	2.9	2.8	202.5	65.8
Latvia – Łotwa	13.8	15.4	36.2	37.5	4.8	5.3	445.8	475.3
Lithuania – Litwa	35.2	35.9	88.7	80.7	10.4	10.9	206.7	156.6
Hungary – Węgry	67.3	63.9	138.4	132.1	19.9	19.2	1 499.9	1 250.6
Poland – Polska	279.5	257.3	597.8	566.5	87.1	82.1	15 746.7	15 666.7
Romania – Rumunia	168.1	140.8	482.5	413.8	34.3	30.6	788.4	1 310.1
Slovenia – Słowenia	18.0	16.9	52.4	49.6	2.9	2.8	236.5	209.1
Slovakia – Słowacja	24.1	24.1	51.0	49.3	6.8	6.7	102.5	87.3

Source: own elaboration based on Eurostat (selections: env_air) data.
Źródło: opracowanie własne na podstawie danych Eurostat (ścieżka wyboru: env_air).

livestock buildings and places where feces are stored, as well as during their distribution in the field. Dropping ammonia contributes to the pollution of surface water and soil acidification. The source of environment contamination by ammonia may be urean artificial fertilizer used in agriculture – urea. For the environment it is important to reduce penetration of ammonia into the air by following the principles of hygiene in livestock and proper management of animal waste. Obsolescence droppings should be removed regularly to the dung plate. In the case of sheds without litter, the time of the passage of faeces to rain-tight tanks should be as short as possible. Fertilizing fields with manure and nitrogen fertilizers we should remember to mix them with the soil as fast as possible (Duer et al., 2004). One of the ways to reduce diffusion of ammonia into the atmosphere is also the applications of liquid manure to soil (Marcinkowski, 2010).

Among the others, the animal production is linked with the release of nitrous oxide into the atmosphere. It is estimated that in Poland, agriculture is responsible for about 76% of the total emissions of the gas (Bobrecka-Jamro and Janowska-Miąsik, 2014). Almost half of agriculture emission has its source in crop fields, 25% from animal production and the remaining emission is indirect (Sapek et al., 2002). There are no special recommendation for methods used in limitation of nitrous oxides limitation into the atmosphere besides limiting the dissipation of nitrogen to the environment (Sapek, 2008).

In 2012, the average emissions of ammonia from agriculture EU was 0.25 kg per 1000 euro of GDP and 19.49 kg per 1 ha UAA. The highest emission of ammonia from agriculture after calculation on 1000 euro GDP was noted in Lithuania (1.08 kg) and in Romania (1.05 kg) (Table 3). These values are the result of relatively low GDP because in consideration of ammonia emission per 1 ha the highest values were achieved in Slovenia (36.69 kg), Poland (18.43 kg) and the Czech Republic (16.83 kg), in countries where animal production is well-developed (Table 4). The lowest emission of ammonia to the environment (after accounting for

Table 3. Greenhouse gas emissions and air pollution to the environment from agricultural of the Central-Eastern Europe countries in 2008 and 2012 (kg per 1000 euro GDP)
Tabela 3. Emisja gazów cieplarnianych i zanieczyszczeń powietrza do środowiska z rolnictwa państw Europy Środkowo-Wschodniej w latach 2008 i 2012 (kg na 1000 euro PKB)

Specification Wyszczególnienie	Ammonia Amoniak		Methane Metan		Nitrous oxide Podtlenek azotu		Carbon dioxide Dwutlenek węgla	
	2008	2012	2008	2012	2008	2012	2008	2012
EU (28 countries) – UE (28 krajów)	0.27	0.25	0.76	0.70	0.07	0.06	7.41	6.94
Bulgaria – Bułgaria	0.80	0.52	1.65	1.37	0.24	0.23	32.02	26.29
Czech Republic – Czechy	0.40	0.33	0.79	0.74	0.12	0.11	7.39	6.97
Estonia	0.61	0.56	1.29	1.24	0.17	0.15	12.26	3.65
Latvia – Łotwa	0.57	0.69	1.48	1.69	0.19	0.24	18.27	21.39
Lithuania – Litwa	1.08	1.08	2.71	2.42	0.32	0.33	6.32	4.70
Hungary – Węgry	0.63	0.65	1.29	1.34	0.19	0.19	14.00	12.67
Poland – Polska	0.77	0.67	1.64	1.47	0.24	0.21	43.30	40.57
Romania – Rumunia	1.18	1.05	3.39	3.09	0.24	0.23	5.54	9.79
Slovenia – Słowenia	0.47	0.47	1.38	1.38	0.08	0.08	6.23	5.81
Slovakia – Słowacja	0.37	0.33	0.78	0.68	0.10	0.09	1.56	1.21

Source: own elaboration based on Eurostat (selections: env_air) data.
Źródło: opracowanie własne na podstawie danych Eurostat (ścieżka wyboru: env_air).

Table 4. Greenhouse gas emissions and air pollution to the environment from agriculture of the Central-Eastern Europe countries in 2008 and 2012 (kg per 1 ha UAA)
Tabela 4. Emisja gazów cieplarnianych i zanieczyszczeń powietrza do środowiska z rolnictwa państw Europy Środkowo-Wschodniej w latach 2008 i 2012 (kg na 1 ha UR)

Specification Wyszczególnienie	Ammonia Amoniak		Methane Metan		Nitrous oxide Podtlenek azotu		Carbon dioxide Dwutlenek węgla	
	2008	2012	2008	2012	2008	2012	2008	2012
EU (28 countries) – UE (28 krajów)	20.36	19.49	56.70	54.70	5.16	4.90	555.00	544.56
Bulgaria – Bułgaria	9.50	4.95	19.73	12.65	2.86	1.91	382.60	180.03
Czech Republic – Czechy	18.40	16.83	36.19	33.99	5.55	5.16	337.94	324.30
Estonia	11.19	9.99	23.47	22.44	3.18	2.73	223.29	61.03
Latvia – Łotwa	7.78	7.93	20.41	19.39	2.68	2.70	251.30	262.67
Lithuania – Litwa	13.30	12.58	33.48	29.20	3.94	3.68	78.03	64.43
Hungary – Węgry	15.92	13.82	32.72	27.99	4.71	3.96	354.70	311.25
Poland – Polska	18.06	18.43	38.62	40.80	5.63	5.71	1 017.41	1 119.35
Romania – Rumunia	12.22	10.91	35.08	31.48	2.49	2.51	57.32	78.91
Slovenia – Słowenia	36.75	36.69	107.23	106.82	5.88	5.93	483.85	430.00
Slovakia – Słowacja	12.44	12.60	26.31	25.43	3.50	3.60	52.93	57.02

Source: own elaboration based on Eurostat (selections: env_air) data.
Źródło: opracowanie własne na podstawie danych Eurostat (ścieżka wyboru: env_air).

1 ha UR) was noticed in Bulgaria (almost 5 kg), Latvia (7.93 kg) and in Estonia (almost 10 kg), according to on 1000 euro GDP conversion in Czech Republic and Slovakia (for 0.33 kg per country). In comparison to 2008 emission of this chemical per 1000 euro GDP increased both in Latvia and in Hungary. However, this increase was primarily caused by a decrease in the value of GDP (Latvia further increased emission of ammonia from agriculture)[5]. In the other countries included in the analysis of the emissions of the mentioned gas per 1000 euro GDP decreased or, as in the case of Lithuania and Slovenia, remained at the same level (due to the fact that a total emissions in Lithuania has increased, and in Slovenia the decline in GDP has been noticed). By analysing the changes in the emission of ammonia per 1 ha UAA it can be stated that emission of mentioned gas has not decreased in Latvia, Poland, Slovenia and Slovakia. In the other countries included in the study, emission of the discussed contamination from agriculture to environment in conversion per 1 ha UAA was reduced. The largest decrease was achieved in the Bulgarian agriculture. However, it resulted mainly from an increase in the surface of UAAby over 1.6 million hectares[6] in the reduction of ammonia emissions by about 8 thousand tons.

The release of nitrous oxide from agriculture into the atmosphere in 2012 in the European Union amounted to an average of 0.06 kg per 1000 euro GDP and 4.90 kg per 1 ha UAA (Table 3, 4). Among the countries of Central-Eastern Europe with the highest emissions of nitrous oxide from agriculture to the environment per 1000 euro GDP in 2012 were observed in Lithuania (0.33 kg),

[5] Reduction of GDP in these countries and increase pollution from Latvian agriculture were affected in the same way on the value of emissions of methane, carbon dioxide and nitrous oxide per 1000 euro GDP.

[6] The increase of UAA in Bulgaria was the main reason for reducing the value of pollution from agriculture per 1 ha UAA. Such a large increase in the UAA may result from the inclusion of grounds previously not used for agricultural use in order to obtain support from the CAP.

Latvia (0.24 kg), Bulgaria and Romania (0.23 kg) (Table 3). In all the countries of Central-Eastern Europe emissions of pollutants per 1000 euro of GDP were higher than the average observed values in the EU (only the values for Slovenia and Slovakia are close to the EU average). However, Slovenia recorded the highest level of nitrous oxide emissions per 1 ha (5.93 kg) (Table 4). Large values of the discussed emission from agriculture to the atmosphere were also observed in Poland (5.71 kg/1 ha) and the Czech Republic (5.16 kg/1 ha). Low emissions of nitric oxide from 1 ha was characterized by Bulgaria (1.91 kg), Romania (2.51 kg), Estonia and Latvia (about 2.7 kg). In comparison to 2008, the release of the mentioned chemical compounds (after conversion per 1 ha UAA) was most significantly limited by Bulgaria, Hungary and Estonia. The expected direction of change in emissions of this pollutant was also observed in Lithuania and the Czech Republic.

Methane is the other gas, emitted from agriculture, negatively influencing the environment. It's responsible in about 18% for the greenhouse effect and its rate of climate warming is about 21 times higher than that of carbon dioxide. In Poland, about 31% of the total methane emissions to the atmosphere derives from agriculture (Bobrecka-Jamro and Janowska-Miąsik, 2014). Methane is formed mainly in agriculture during the enteric fermentation of animals and both the storage and use of manure and slurry. Therefore, one of the most effective ways to reduce emissions to the atmosphere of this compound its proper management. Reduction of methane emissions from the atmosphere positively affects the proper selection of nutrients in feed and animal production in agricultural areas of energy crops. The greatest potential for reducing methane emissions to the environment has the disposal of animal manure and the use of agricultural biomass in biogas industrial plants (Bartkowiak, 2010).

In the EU, the average emission of methane per 1000 euro GDP was 0.70 kg and for 1 ha UAA 54.70 kg (Table 3, 4). As in the case of ammonia the highest methane emissions from agricultural sources based on EUR 1000 GDP were recorded in Romania (more than 3 kg) and Lithuania (2.40 kg) (Table 3). Slovenia is a country where methane emissions from agriculture per 1 ha were almost twice higher than in the EU (almost 107 kg) (Table 4). Countries in the area of Central-Eastern Europe with a high level of emissions linked to the mentioned situation were also Poland (40.80 kg), Czech Republic (nearly 34 kg) and Romania (over 31 kg). According to conversion per 1 ha UAA, the lowest emission of methane from agriculture sources to the environment was observed in Bulgaria (12.65 kg). This may be due to the high share of crop production in the Bulgarian agriculture. In 2012, only Poland shared a slight increase in methane emissions per 1 ha (about 2 kg) in comparison with 2008. In other countries included in the analysis the emission was reduced. According to conversion per 1000 euro GDP methane emissions from agriculture, it increased only in Latvia and Hungary. The direction of changes in methane emissions in relative terms in the countries of Central-Eastern Europe is desirable from the point of view of environmental protection. These changes may be a consequence of the implementation of the pro-environmental principles of the CAP by farms.

Carbon dioxide is another chemical compound that causes the greenhouse effect. Its considerable amounts arise during agricultural production. Agriculture has also an important role in sequestration (binding) of carbon dioxide from the atmosphere. Its greatest intensity is done on forest land and permanent grassland (Sapek, 2009). Therefore, from the point of view of environmental protection, in cultivation, monocultures should be avoided. Monocultures lead to the destruction of the soil structure and excessive air entrainment ending with a release of carbon dioxide into the atmosphere (Kasprowicz et al., 2011). Reducing carbon dioxide emissions from agriculture can be carried out also through the use of renewable energy sources for heating, reducing heat loss in buildings, adequate ventilation and a reduction in fuel consumption, which from the point of view of advancing processes of agricultural mechanization seems to be difficult to achieve (Duer et al., 2004).

In 2012, agriculture in the European Union, the emission of carbon dioxide amounted to 6.94 kg on 1000 Euro GDP and 544.56 kg on 1 ha UAA (Table 3, 4). Among the countries of Central-Eastern Europe the highest carbon dioxide emissions per 1000 euro GDP were recorded in Poland (almost 41 kg), Bulgaria (over 26 kg) and Latvia (around 21 kg) (Table 3). Poland is a country which also reported the highest emission of this compound per 1 ha UAA (nearly 1120 kg) (Table 4). Slovakia and Estonia are countries in which carbon dioxide emissions both per Euro 1000 GDP and per 1 ha UAA were low. Compared to 2008, the biggest reduction in carbon dioxide emissions per 1 ha UAA and 1000 euro of GDP was recorded in Bulgaria and

Table 5. Direct material input (DMI) and domestic material consumption (DMC) of biomass from agriculture of Central-Eastern Europe countries in 2004 and 2013
Tabela 5. Bezpośrednie nakłady materialne (DMI) i krajowa konsumpcja (DMC) biomasy z rolnictwa państw Europy Środkowo-Wschodniej w latach 2004 i 2013

Specification Wyszczególnienie	DMI (thous. ton) DMI (tys. ton)		DMI (thous. ton) DMC (tys. ton)		DMC/GDP (kg/EUR) DMC/PKB (kg/euro)		DMI/GDP (kg/EUR) DMI/PKB (kg/euro)	
	2004	2013	2004	2013	2004	2013	2004	2013
EU (28 countries) – UE (28 krajów)	1 927 318	1 884 003	1 828 359	1 729 689	0.17	0.13	0.17	0.14
Bulgaria – Bułgaria	84 904	84 030	48 176	47 016	2.30	1.15	4.06	2.05
Czech Republic – Czechy	43 010	46 564	26 650	20 373	0.28	0.13	0.45	0.30
Estonia	9 275	11 820	4 508	5 465	0.46	0.29	0.96	0.62
Latvia – Łotwa	31 522	33 737	22 667	21 534	1.93	0.93	2.69	1.45
Lithuania – Litwa	20 546	30 061	16 941	20 896	0.93	0.60	1.13	0.86
Hungary – Węgry	58 658	48 050	49 394	33 018	0.59	0.33	0.71	0.48
Poland – Polska	187 260	201 032	174 589	173 234	0.85	0.44	0.91	0.51
Romania – Rumunia	80 109	81 317	75 355	61 860	1.23	0.43	1.30	0.56
Slovenia – Słowenia	10 621	10 643	6 605	3 946	0.24	0.11	0.38	0.30
Slovakia – Słowacja	25 048	24 307	20 292	16 149	0.58	0.22	0.72	0.33

Source: own elaboration based on Eurostat (selections: env_mrp) data.
Źródło: opracowanie własne na podstawie danych Eurostat (ścieżka wyboru: env_mrp).

Estonia. Countries, which from the point of view of environmental protection, was observed undesirable direction of changes in carbon dioxide emissions per 1000 euro GDP, are Latvia and Romania. In these countries, there was also an increase in the emission of this compound per 1 ha UAA. The same trend is also marked by changes in Poland and Slovakia. Due to the highest emissions of carbon dioxide from Polish agriculture, actions to reduce emission should be intensified.

Attempt to assess the level of sustainability of agriculture can be realized also by analysing the amount of biomass that is produced in agriculture and is used in the economy. For this purpose, in the study were used indicator of direct material input (DMI, biomass mainly from agriculture) and the index of domestic materials consumption (DMC). To determine the material consumption in economic those indicators were converted to the GDP countries of Central-Eastern Europe. In this way, we defined the intensity of use of the environment expressed by the quantity of material use per unit of production.

In the EU territory, a decrease in the intensity of use of natural resources in the form of lower production and consumption of biomass is observed (Table 5). But among the majority of countries in Central-Eastern Europe an increased intensity is observed in the production of biomass. Only in Hungary and Slovakia, the situation was reversed. In all countries included in the research domestic biomass production was higher than its consumption, which is a favourable situation. Only in Lithuania and Estonia an increase in the consumption of biomass was noted in the national economy. Analysing the changes in the intensity of use of environmental resources in the countries included in the study it can be concluded that the production and consumption of biomass per 1 euro of GDP is reduced. This indicates dematerialising of the economies of these countries. It is a desirable direction of changes from the perspective of the environmental care. In 2012 in comparison to 2004 to 1 euro of GDP the biomass production in Romania and Slovakia was reduced by more than a half, and its consumption by over 60%. These results resulted partly

from the higher growth of GDP in these countries compared to other countries included in the analysis. Over 50% reduction in the use of biomass were also noted in Bulgaria, Latvia and Slovenia. The slowest rate of pro-environmental changes in the use and production of biomass was observed in Lithuania and Estonia.

SUMMARY

Based on the conducted study, it was found that in 2008–2012 the emission of harmful compounds from agriculture of countries of Central-Eastern Europe into the atmosphere per 1000 euro GDP decreased. A similar trend was observed in emissions per 1 ha UAA. The dynamism of changes in the production and use of biomass is faster in the countries of Central-Eastern Europe than across the Union. This is due to the fact that in the western part of Europe action in favour of sustainable development has a long history and changes in this area have been already made. Countries of Central-Eastern Europe (and thus the agricultural sector in these countries) only enter the path of sustainable development and the changes in the environment are more dynamic.

The conducted preliminary attempt to use input-output balance sheets to assess the sustainability of the agricultural sector in the countries of Central-Eastern Europe indicated that balances can be a useful tool in assessing the implementation of this concept. The input in agriculture showed a significant dependence of agriculture on other sectors of the national economy (including the fuel and energy industry and chemical). On the other hand, the agricultural farm materials are still insufficiently used for the production of other non-food products. A useful tool in the evaluation of sustainable development of agriculture are the data from the European Environmental Accounts, or satellite accounts to national accounts, which are the main base for the creation of input-output balance sheets. The results of calculations of emissions of greenhouse gases and pollutants into the environment from agriculture showed a decreasing impact on the environment, or dematerialising economy. It takes the phenomenon to separate economic growth from the rate of use of natural resources and environmental degradation, increase productivity (efficiency) resources. In summary it can be stated that in countries where agriculture is better developed, the implementation of pro-environmental goals of sustainable development takes place to a greater extent than in countries with lower levels of socio-economic development. Increase of the productivity (efficiency) of resources takes place in case of separation of economic growth from the rate of use of natural resources and environmental degradation.

In conclusions it has to be stated that due to lack of data, the analysed problem was successfully discussed but to a limited scale. However, the conducted analyses prove that the use of data from balance of input-output can be very useful to explain new events and processes in agriculture, related to the concept of sustainable development.

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PRÓBA OCENY WPŁYWU ROLNICTWA NA ŚRODOWISKO W PAŃSTWACH EUROPY ŚRODKOWO-WSCHODNIEJ

Streszczenie. Głównym celem artykułu było zidentyfikowanie i ocena postępów realizacji wybranych założeń zrównoważenia rolnictwa państw Europy Środkowo-Wschodniej w odniesieniu do aspektów związanych z ochroną środowiska. Do realizacji celu wykorzystano dane z Bilansów przepływów międzygałęziowych oraz Europejskich Rachunków Środowiska. Przeanalizowano przepływy materiałowe z/do rolnictwa, emisję zanieczyszczeń oraz produkcję i konsumpcję biomasy. W napływach materiałowych do rolnictwa państw Europy Środkowo-Wschodniej wzrasta udział sfery I agrobiznesu, w tym głównie usług oraz przemysłu paliwowoenergetycznego i chemicznego. Wskazuje to na unowocześnienie produkcji, wiąże się jednak z większym obciążeniem środowiska naturalnego. Najwyższą emisję gazów cieplarnianych i zanieczyszczeń powietrza do środowiska w przeliczeniu na 1000 euro PKB odnotowano w Litwie, Rumunii i Łotwie. Czechy, Słowenię i Słowację cechuje najniższa emisja ww. zanieczyszczeń powietrza. Łotwa jest państwem, w którym nie zaobserwowano redukcji zanieczyszczeń ogółem emitowanych przez rolnictwo w latach 2008–2012. W większości państw objętych analizą emisja omawianych zanieczyszczeń w przeliczeniu na 1000 euro PKB oraz 1 ha UR uległa zmniejszeniu. W krajach UE położonych na obszarze Europy Środkowo-Wschodniej odnotowano zmniejszenie bezpośrednich nakładów materiałowych i krajowej konsumpcji biomasy z rolnictwa w przeliczeniu na jedno euro PKB. Zmiany te wskazują na zmniejszenie intensywności korzystania z zasobów środowiska (odmaterializowanie gospodarki), co jest zgodne z założeniami zrównoważonego rozwoju. Reasumując, w państwach, w których rolnictwo jest lepiej rozwinięte, realizacja prośrodowiskowych celów zrównoważonego rozwoju jest lepsza niż w krajach o niższym poziomie rozwoju społeczno-gospodarczego.

Słowa kluczowe: zrównoważony rozwój, rolnictwo, zanieczyszczenie powietrza, biomasa

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