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CHANGES IN THE ENVIRONMENTAL IMPACT OF POLISH AGRICULTURE AFTER THE ACCESSION TO THE EUROPEAN UNION

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Abstract. The purpose of this paper is to demonstrate the changes in environmental impact of Polish agriculture and to determine the conditions of this process during Poland's membership in the European Union. This paper presents the results of surveys on changes in emission of pollutants and in other impacts of agricultural production on water, climate and biodiversity in 2003–2015. Based on statistical data and factual information, the author conducted a descriptive and comparative analysis of the processes in question. The study period witnessed a 50% increase in fertilization rates together with the related impact on greenhouse gas emission from agricultural soils and a three-fold increase in the consumption of plant protection products (as well as the increased use external productive inputs). All of these developments were driven by direct payments from the Common Agricultural Policy (CAP). The changes in environmental impacts of agriculture prove that after joining the EU, changes towards production intensification were accompanied by an increased direct pressure on water quality. Changes in livestock production emissions were not directly related to instruments under the first pillar of the CAP. The direct regulatory instruments for environmental protection failed to sufficiently mitigate the increase in the discharge of nitrates into water and in greenhouse gas emissions (2.4% in 2003–2015) and the harmful impacts on biodiversity.

Keywords: environmental protection in agriculture, agricultural pressure on the environment

INTRODUCTION

The purpose of this paper is to describe the changes in environmental impact of Polish agriculture and to indicate the circumstances behind this process. These are important factors with external effects that perturb the efficient operation of the market mechanism. They contribute to a situation where market equilibrium is not Pareto optimal (Dasgupta and Heal, 1979). In the light of economics of welfare, it is desirable to conduct scientific research into the environmental reasons for agricultural externalities. This paper presents the results of surveys on the emission of pollutants and other human pressures reflected by the impacts of agricultural production on three selected components of the environment: water, air (climate) and biodiversity. These processes were put in the context of instruments deployed under the Common Agricultural Policy (CAP) and of the European Union's (EU) environmental policy. The former affect the intensity of production methods while the latter may mitigate the environmental pressures of agriculture.

The agriculture accounts for 50% to 80% of total volume of nitrates discharged into water (Commission…, 2013). In 2015, according to author's measurements based on Central Statistical Office data (2004–2018), the agriculture sector was responsible for 9.8% of yearly greenhouse gas (GHG) emissions in the UE-27 (current 27 member states). Agricultural water pollutants mainly include nitrates and phosphorus compounds

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which cause eutrophication. The emissions result from the use of fertilizers and livestock breeding, and are exacerbated by improper storage of animal feces. Agricultural GHG emissions mainly comprise N_2O emitted by meadows under the action of fertilizers (50.4% of agricultural GHG emissions in UE-27) (Commission…, 2009). Other sources of emission are related to animal production: manure management and enteric fermentation account for 15.6% and 32% of GHG, respectively.

METHODOLOGICAL ASPECTS

The environmental impacts of agriculture were described for the 2003–2015 period (extended to 2016 or 2017 in some cases), i.e. from the year preceding the accession to the EU until statistical data is available. Based on data and factual information, a descriptive and a comparative analysis was performed. The first (dynamic) one focused on the process and conditions of environmental pressures experienced in Poland. It was used to reveal the circumstances behind changes in emissions after the EU accession. In that period, environmental impacts could be influenced by the implementation of CAP instruments and of the environmental policy, and were therefore analyzed in the context of these measures. While the first one could stimulate production intensification (together with its environmental externalities), the second one could mitigate that impact. To present long-term climate changes, two time intervals were compared: 1988–2015 (from the base year set by the Intergovernmental Panel on Climate Change, IPCC) and 2003–2015 (from the accession to the EU). To investigate the impact of Poland's accession on agricultural pressures, the author carried out a comparative analysis referring to similar developments taking place across the EU. The author relied on data published by the Central Statistical Office, National Center for Emissions Management (KOBiZE), Eurostat, European Environment Agency (EEA), Commission of European Communities, on information from strategic documents of the EU and on results of scientific research carried out nationally and internationally.

The KOBiZE methodology takes seven greenhouse gases into consideration: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), HFC (fluorocarbons), PFC (perfluorocarbons), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). They are reported in 5 categories (including agriculture). The calculation of emissions and discharge of greenhouse gases was based on the IPCC methodology[1].

RESULTS

Agricultural pollution of water

After joining the EU (2003–2017), Poland witnessed a rapid growth of consumption of mineral fertilizers (Fig. 1). According to the author's calculations, the general fertilization rate (NPK: nitrogen, phosphorus, potassium) grew by 50% p.a., from 93.5 kg/ha of UAA (Utilized Agricultural Area) in 2003 to 140.4 kg/ha of UAA in 2017. This mainly concerns potassium (as a pure ingredient) with a total annual consumption growth rate of 63% (from 23.4 kg/ha of UAA to 38.1 kg/ha of UAA). At the same time, the consumption of nitrogen and phosphorus went up from 51.5 kg/ha of UAA to 78.8 kg/ha of UAA (by 52%) and from 18.7 kg/ha of UAA to 23.5 kg/ha of UAA (by 26%), respectively. A large increase in the NPK fertilization rate (by 20.4%) was observed between 2005 and 2006, i.e. in the

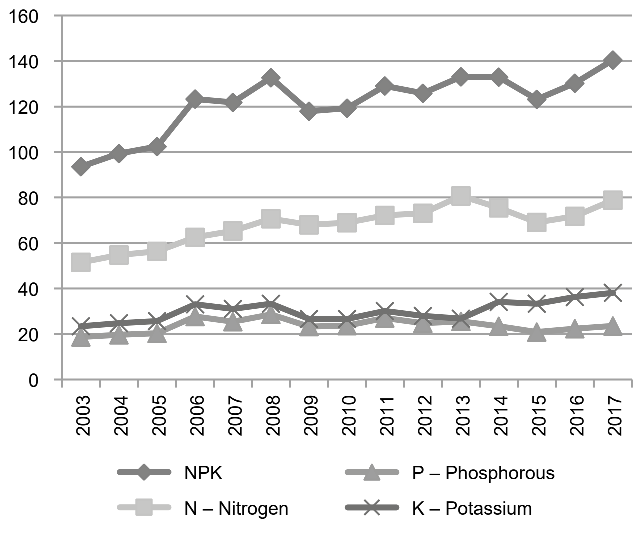

Fig. 1. Consumption of mineral fertilizers (pure ingredients) (kg per ha of UAA)
Source: own elaboration based on Central Statistical Office data (2004, 2011, 2018).

[1] For detailed information on the methodology used by KOBiZE, see the dedicated report (KOBiZE, 2018).

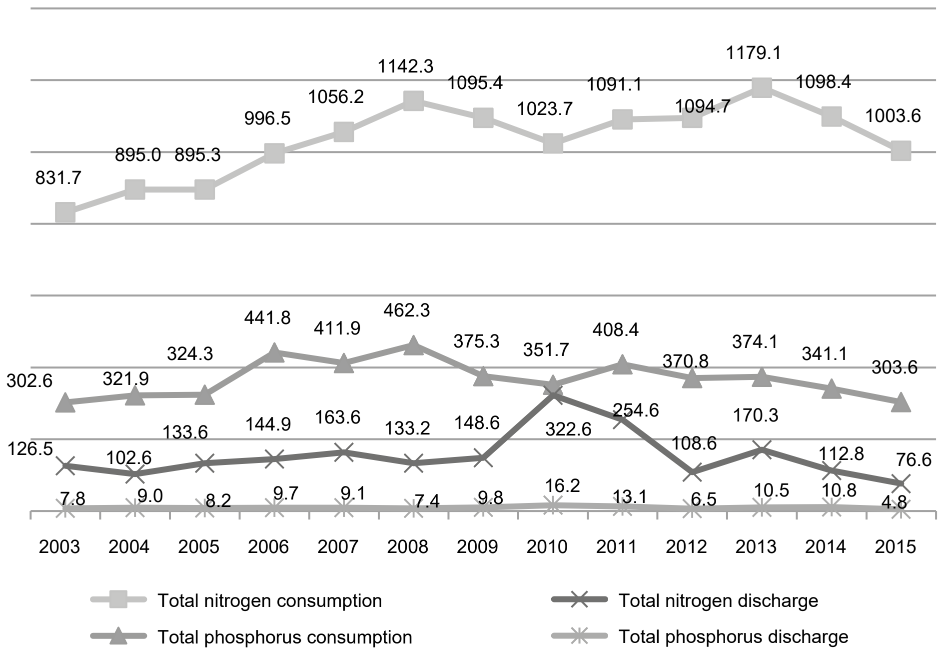

Fig. 2. Consumption of mineral fertilizers and discharge of biogenic substances through Polish rivers to the Baltic Sea (pure ingredients, thousand tons).
Source: own elaboration based on Central Statistical Office data (2004–2018): (2004, 2011, 2018).

implementation period of direct payments which provided the agriculture with more opportunities to access external funds. This had an impact on the intensification of production methods and on the sector's industrialization (Woś, 2003). The consumption of fertilizers (especially including nitrogen and phosphorus) was observed to decline periodically from 2008 to 2010 and from 2014 to 2015. In the first of the above periods, it resulted from poor prosperity which, in turn, echoed the global economic crisis. The second decline was the consequence of the reform in the direct payments system for 2014–2020. The farmers had to adjust to changes, including the environmental requirements for direct payments (greening).

As a result of increased consumption of mineral fertilizers, the annual nitrogen load discharged to the Baltic Sea went up by 19.5% in 2003–2009 (Fig. 2). Then, a rapid increase was observed in 2010 as a result of a flood, but was followed by a downward trend. In the entire study period (2003–2015), the total discharge of nitrogen and phosphorus into the Baltic Sea went down by 39.5% and 38.5%, respectively. Nevertheless, this did not result from a reduction in emissions from the agriculture sector where the total annual nitrogen consumption went up by 20.5% (2003–2015). If the analysis additionally includes 2016 data (not included in Fig. 2), it can be calculated that the growth in nitrogen and phosphorus consumption in agriculture in 2003–2016 was 25% and 7.5%, respectively.

Note that phosphorus contributes to eutrophication more than nitrogen does. The declines in total nitrogen and phosphorus emission resulted from a general improvement in water protection.

This is related to enhancements in municipal sewage management. In 2003–2016, municipal discharge volumes went down by 24% (nitrogen) and 56% (phosphorus) (GUS 2004–2018).

The agricultural impacts on water quality were mainly driven by the increased use of mineral fertilizers. In the study period, livestock density changed only slightly (from 0.44 LSU/ha[2] in 2003 to 0.45 LSU/ha in

[2] Livestock units (LSUs) per hectare of UAA: livestock density index.

2017) (GUS 2005–2018). As a consequence, manure consumption remained at a steady level of 46.3 kg NPK/ha both in 2003 and 2017 (GUS, 2004–2018). In 2008, as a result of the increased rate of nitrogen fertilization in Poland (Fig. 1), the nitrogen consumption level (70.7 kg/ha of UAA) exceeded the EU-27 average (64 kg/ha of UAA). In the same year, that rate was close to the average level (72 kg N/ha of UAA) for old EU members (EU-15) (Eurostat, 2010). In 2015, the EU-level average was 74.4 kg/ha, i.e. 3.2% higher than in Poland (72.1 kg/ha of UAA) (Eurostat, 2017). In the same year, nitrogen consumption in the Netherlands, Czech Republic and Belgium was 137.1 kg/ha of UAA, 114.8 kg/ha of UAA and 108.7 kg/ha of UAA, respectively. These were the countries reporting the EU's highest level of mineral nitrogen consumption per hectare. Before Poland joined the Union (in 2003), domestic phosphorus consumption was consistent with the average level for the EU. In 2015, the rate for Poland (20.5 kg/ha UAA) was 9% above the EU average (19 kg/ha)[3]. In the EU, the largest amounts of phosphorus are used in Cyprus (38.2 kg/ha) and Ireland (27.5 kg/ha) (GUS, 2017). In Belgium and Czech Republic, the consumption level is ca. 10 kg/ha (vs. 7.1 kg/ha in the Netherlands). The trend towards increasing the fertilization rate gives way to an opposite tendency, as may be observed in the entire EU which has experienced a long-term reduction in the average fertilization rate[4]. The above suggests that CAP instruments, depending on when and in what conditions they are used, have diverse effects on the environmental impacts of agriculture. The EU's agriculture (which underwent the intensification process decades earlier) has been reducing its pressure on the environment under the influence of modified CAP instruments. Along with subsequent CAP reforms, certain incentives promoting production intensification were reduced since subsidies no longer depend on production volume (decoupling). Other measures implemented are *cross-compliance* (mandatory environmental standards for beneficiaries of direct payments) and modulation, i.e. the transfer of funds from the first to the second pillar of the CAP (Kociszewski, 2016). Besides, there was a strengthening in agri-environmental programs and support for organic farming; in 2014–2020, were partly destined for the mandatory greening of farms. Also of importance was the implementation of the Nitrates Directive[5]. These measures resulted in reduced consumption of fertilizers and improved management of livestock feces. The relatively extensive Polish agriculture sector, influenced by the already reformed instruments (after accession) moves towards intensification and exerts a growing pressure on the environment.

Additionally, Poland was ineffective in implementing the requirements for agriculture provided for in the EU's environmental policy. The Nitrates Directive requires Nitrate Vulnerable Zones (NVZs) to be designated and adequate protective operations to be performed. To date, small amounts of water resources susceptible to nitrogen pollutants have been covered by the Polish NVZs, which means that the knowingly growing pressure of agriculture on water quality has not been sufficiently addressed. In 2004–2008, the standards of the Nitrates Directive were mandatory in 2% of the Polish territory. Afterwards (2008–2012), the area in question was reduced to 1.5%. In 2012–2016, it extended over 4.5% of the country. Meanwhile, the share of the NVZs in the territory of EU-27 countries was 46.7% in 2013 (Commission of European Communities, 2013). Hence, in 2013, the European Commission seized the EU Court of Justice to rule on the absence of an effective solution to this issue. In 2014, the Court found these allegations justified, and urged the Polish authorities in 2017 to establish NVZs across the country through an amendment to the Water Law Act from 2017[6].

Agriculture and greenhouse gas emissions

According to IPCC, agricultural production is the second largest source of GHG emissions in Poland, after the energy industry which accounts for 82% of domestic GHG emissions. In 2016, the agriculture sector emitted

[3] Author's own elaboration based on GUS (2004–2018).

[4] In 2011, annual consumption of nitrogen fertilizers in the EU was by nearly 30% lower, and annual consumption of phosphorus fertilizers was by ca. 70% lower than in 1987 when it reached the highest level ever recorded (Kociszewski, 2016). In 2011–2015, according to the author's calculations based on GUS (2004–2018), the fertilization rate went up by 10%. This was largely driven by changes taking place in member states, including Poland.

[5] Council Directive 91/676/EEC of December 12, 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (Official Journal L 375, Dec 31, 1991).

[6] Water Law Act of July 20, 2017 (Ustawa z dnia 20 lipca 2017 r. – Prawo wodne, Dz. U. z 2017 r., poz. 1566).

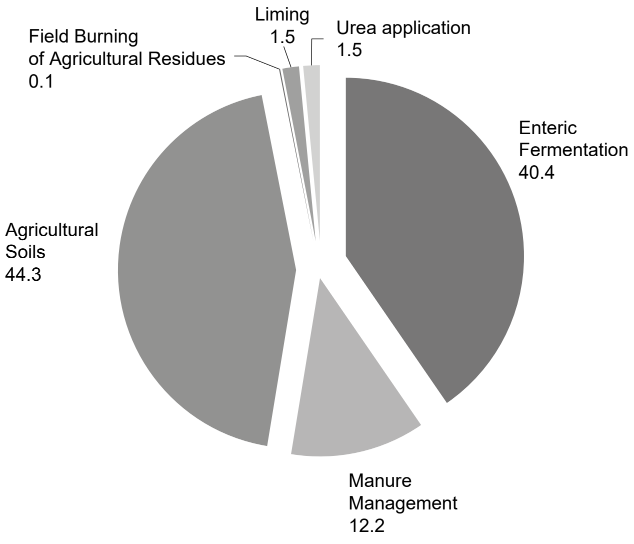

Fig. 3. Shares of agricultural sources of GHG emissions in 2014 (%)
Source: author's own elaboration based on KOBiZE (2016).

29.6% of methane, 77.6% of N_2O and just 0.3% of CO_2 released into air by the Polish economy (KOBiZE, 2018). In 2003–2016, the share of agriculture in total GHG emissions in the Polish economy was ca. 10–11% (10.3% in 2016)[7]. The largest source of agricultural GHG emissions are agricultural soils used for plant production (Fig. 3). Because mineral and natural fertilizers are used, substances released by soil include N_2O. Enteric fermentation and manure management also play an important role. These two sources are a side effect of animal production, and jointly account for 52.6% of agricultural emissions.

According to the author's calculations based on KOBiZE (2018), annual agricultural GHG emissions went up by 2.4% from 2003 to 2016. At the same time, total annual emissions in Polish economy went down by 0.5%. The increase in agricultural emissions after Poland's accession to the EU should be compared to a long-term decrease in emissions which took place in 1988–2016. The decrease rate was 30.4%, i.e. slightly higher than the corresponding ratio for the entire economy (29%), and resulted from a reduction in animal production volumes. In 1988–2016, cattle numbers decreased by 40% (including 44% for non-dairy cattle) while the reduction in pig and sheep numbers was 44% and 94%[8], respectively.

In a long-term perspective (1988–2016), emissions from agricultural soils also went down (by 27%) (KOBiZE, 2018). However, after joining the EU, Poland witnessed the emergence of an opposite trend. In 2003–2016, the emissions increased by 9%. From 1988 to 2016, emissions from enteric fermentation (CH_4) went down by 44% as a consequence of a drop in livestock numbers (especially including cattle which accounts for 90% of enteric emissions). After Poland joined the EU (2003–2016), emissions from this source went up by 3%. It mainly resulted from an increase in non-dairy cattle numbers (and was accompanied by a general drop in livestock numbers). These developments were not affected by the instruments of the first or second pillar of the CAP. The opportunities to sell (products) in the European Single Market could be important to a certain extent, and so could be the mechanisms related to milk quotas which had in indirect impact on the size and structure of animal production.

In 1988–2016, CH_4 and N_2O emissions from manure management decreased by 32% and 36%, respectively. This trend also prevailed in 2003–2016 when CH_4 and N_2O emissions dropped by 14% and 11%, respectively. This was caused by a change in pig numbers which, according to the author's calculations based on KOBiZE data (2018), went down by 41.5%. However, the largest decline (by 67%) took place in 2008–2016, and could result from the global economic crisis. The reduction in emission of both greenhouse gases from pig farming was 39%. Just like in the case of enteric fermentation, it had little to do with CAP instruments and was driven by the changing market situation. While cattle is responsible for 57% of CH_4 emissions from manure management, two different trends can be observed. The emissions from dairy cattle farming dropped (by 1% for CH_4 and by 10% for N_2O) because of a decline in dairy cattle numbers (19.5%). At the same time, the numbers of non-dairy cattle increased by 39%, resulting in a rise in the related emissions (39% for CH_4 and 43% for N_2O). In that period, carbon emissions from liming went up by 33% but increased because of urea application

[7] The estimations do include neither the LULUCF nor the emissions from energy and fuel consumption in agriculture (which are included in the "energy" category). LULUCF mean land use, land-use change and forestry.

[8] Own calculations based on KOBiZE (2018).

(by 17%). Note however that liming has a slight impact on climatic changes.

Based on changes described earlier in this paper, it can be confirmed that after the accession, the intensification of agriculture (combined with increased financial support provided under direct payments) brought adverse environmental impacts. This includes not only water pollution but also the agricultural impact on climatic changes. In this case, the impacts are caused by the growth in fertilization levels, simplified crop rotation, reduced number of plants which enrich the soil with organic matter, and deeper plowing (intensified mechanization of production) (Faber et al., 2012). The increase in total agricultural GHG emissions was mitigated by a reduction in livestock numbers, in particular pigs and non-dairy cattle (due to market conditions), and – to a smaller extent – by certain agri-environmental measures (deployed to a limited extent).

In 1990–2015, measures taken by the EU contributed to a 21.2% reduction in GHG emissions from the Union's agriculture sector, to an 18% increase in agricultural value added, and to a 25.5% reduction in emissions from the entire economy (European Commission, 2015; GUS, 2017). In 2015, the share of agriculture in total GHG emissions from the economy of EU-27 countries was 9.8%, whereas globally, agriculture accounted for 14% of total emissions. The reduction in emissions did not result from the deployment of CAP instruments or environmental policy focused on climate protection but from actions taken to reduce general agricultural pressures on the environment (as listed in the water pollution section). The decoupling slowed down the conversion of meadows into farmland; and the implementation of *cross-compliance* and operations provided for in the Nitrate Directive contributed to a 30% reduction in N_2O emissions from agricultural soils (European Environment Agency, 2015). In animal breeding, methane emissions went down by 20% as a result of restructuring and improved production technologies (smaller herds, increase in milk production volumes) (European Commission, 2014). The reduction in GHG emissions was also supported by the abolition of milk quotas. In 2003–2015, GHG emissions from the EU's agriculture increased by ca. 1%, which was in part influenced by increased emissions from Polish agriculture (by 2.4% during that period). Their share in total agricultural emissions in the EU is 7.5%.

Impact on biodiversity

The agricultural impacts on biodiversity were assessed based on two available indexes: FBI 22[9] and pesticide consumption. Fluctuations of the FBI index do not seem to be coherent with the consequences of CAP instruments implemented in parallel (Fig. 4). FBI 22 went down before the accession and increased after Poland joined the EU, when financial incentives for the intensification of agriculture started to take effect (intensification poses a hazard to birds in rural areas). Then, after some short-term fluctuations, a downward trend has been observed since 2008, although no substantial changes in the functioning of agricultural support instruments took place. In 2003–2017, the index went down by 4.1 percentage points; it seems that this downward trend revealed itself gradually in time. Indeed, the effects of intensification of agriculture are not immediate and can be noticeably delayed.

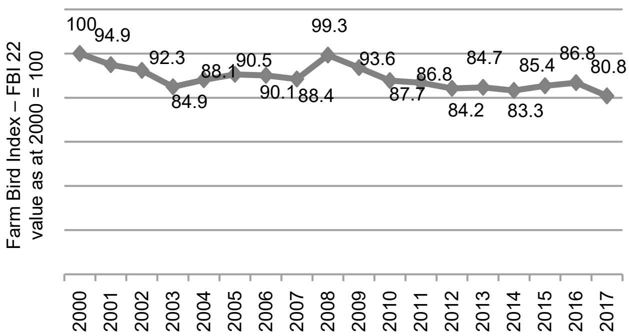

Fig. 4. Changes in Farm Bird Index 22 in Poland in 2000–2017
Source: own elaboration based on GIOS (2018).

A factor affecting biodiversity is the use of plant protection products (Fig. 5). It has an adverse effect on insect populations (including bees), microbes and soil biodiversity.

Considering the role of bees in plant pollination, long term hazards for production capabilities should be taken into account. They are unfavourable for sustainable development of agriculture. In 1999–2003, the use of plant protection products was at a level of

[9] FBI is an index used in the EU to assess rural biodiversity. It is calculated based on the population of 22 birds species typical of rural habitats.

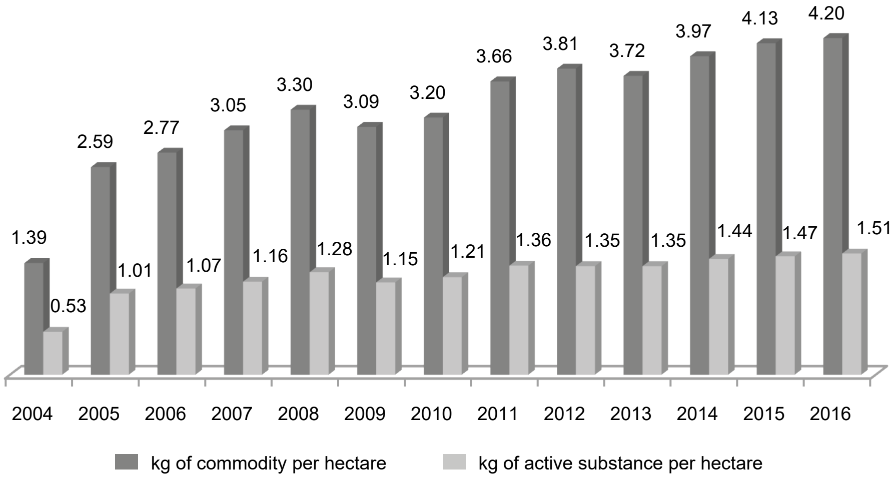

Fig. 5. Consumption of plant protection products in Poland in 2003–2016 (kg/ha of UAA)
Source: own elaboration based on GUS (2005–2018).

0.59–0.56 kg of active substance per ha of UAA (save for some minor fluctuations) (GUS, 2004, 2011, 2018). From 2004, the quantity of plant protection products has been growing steadily (except for one slight decrease in 2009 and 2010, probably related to effects of the global economic crisis).

In 2016, the annual consumption of plant protection products (expressed in kilograms of commodity per hectare of UAA) was three times higher than in 2004. In 2016, the consumption of active substances in kg/ha of UAA was 2.8 times higher than in 2004. This suggests that the inflow of financial resources under the CAP and the market conditions resulting from the participation in the common market resulted in more funds being available for external productive inputs in agriculture. The increase in the use of plant protection products was much more pronounced than in the case of fertilizers. Agricultural pressures on biodiversity grew much more rapidly than pressures on water quality and climatic changes.

CONCLUSIONS

The conditions of changes in environmental pressures may have a direct or indirect effect. The first group are changes in different categories of external productive inputs along with environmental protection regulations. The second ones are factors affecting these changes, i.e. financial incentives such as the first and the second pillar of the CAP. The changes in environmental impacts of agriculture prove that after joining the EU, changes towards production intensification were accompanied by an increased direct pressure on water quality. After accession, the general annual fertilization rate (NPK) and nitrogen emissions went up by 50% and 52%, respectively. Hence, carbon emissions from agricultural soils have been increasing, though less rapidly. Animal production emissions went up, too, especially as regards methane from enteric fermentation (by 3%). It was the effect of an increase in non-dairy cattle numbers (by 39% in 2003–2016). During the same period, N_2O emissions and methane emissions from manure management went down (by 11% and 15%, respectively), mainly because of a decline in pig and dairy cattle numbers (by 41.5% and 19.5%, respectively). The reduction in the emission of both greenhouse gases would be higher if not for the growth in non-dairy cattle emissions (by 39% for CH_4 and by 43% for N_2O). In 2003–2015, total annual GHG emissions from the Polish agriculture went up by 2.4%, i.e. more rapidly than across the EU as a whole (by 1% during the same period). As a result of rapid (three-fold) growth in the consumption of plant protection products, more and more serious hazards to biodiversity emerge in rural areas (where the FBI 22 index was observed to follow a downward trend).

The main groups of CAP instruments affected the changes in environmental pressure of the Polish agriculture in different ways. Direct payments had an effect on the general intensification of plant production, including the increase in fertilization rates together with related impacts on GHG emissions, and the growing consumption of plant protection agents. This is because direct payments ensured an inflow of funds enabling an increase in the amounts of external productive inputs. Changes in livestock production emissions were not directly related to CAP instruments which were neither designed nor used to stimulate an increase in production volumes (Osterburg et al., 2008), and did not contribute to production intensification. The agricultural sector was proved to have a growing impact on water quality and climatic changes. These impacts were insufficiently mitigated by direct regulation instruments (under the Nitrate Directive). Only a slight part of water resources were located within the NVZs. Further changes in the Polish agriculture will largely depend on the scope, effectiveness and coordination of further implementation of instruments under agricultural environment policies, and on the effects of the CAP reform after 2020. A more effective implementation of environmental standards and an enhanced range of environmental instruments under the first and the second pillar of the CAP could stop the upward trend in environmental impacts of Polish agriculture. This is especially true for the agri-environmental program and the greening component of direct payments.

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