PRELIMINARY STUDIES ON THE IMPACT OF ORGANIC AND CONVENTIONAL AGRICULTURE ON THE ENVIRONMENT IN POLAND

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A B S T R A C T

In Poland in the year 2010, 518 527 hectares of agricultural land were managed organically. This study attempts to estimate the total non-monetary value of Polish organic production as a sum of its non-monetary external benefits and the external costs which were offset by the transition from conventional to organic production. The external costs of Polish conventional agriculture were also calculated and a comparison with existing available data from Germany, the UK and the USA was made.

Key words: Polish organic agriculture, external costs, external benefits

INTRODUCTION

Organic agriculture has been developing rapidly worldwide in recent years and its share of agricultural land continues to grow. In the year 2006, more than 30 million hectares of farmland in the world were managed organically, which constituted about 0.65 percent of the global agricultural land. In 2009, already 37 million hectares worldwide were farmed organically, representing approximately 0.9 percent of the total world farmland (Willer and Kilcher, 2011). Europe accounts for 20% of the organically managed area. The local leader in organic farming is still Italy with more than 1.1 million hectares, next come almost side by side: Spain, Germany and the UK, each of them with about 1 million hectares. (The World of Organic Agriculture, 2008). Organic farming combines the

best solutions of the old-fashioned agriculture, like crop rotation, fallowing of land, green manure, mixed cropping (co-cultivation), with modern techniques and science for the benefit of the shared environment and better quality of human life. The adoption of the techniques of organic farming by farmers in developing countries with extensive agriculture has resulted in a rapid 20% to 30% increase in yields (Parrot and Marsden, 2002).

The results of such big and well-known projects as SAFE-World demonstrate the possibilities of organic methods to produce enough food on a global per capita basis to sustain the current human population. Although the farms engaged in this venture did not quite comply with, for example, the EU regulations for the production, control and labelling of organic products, the methods of organic and sustainable agriculture were the basis of the project. At the beginning of the 21st century some 9.0 million farmers on 28.9 million hectares were engaged in this project. That was just over 3% of the total cultivated area (960 M ha) in developing countries of Asia, Africa and Latin America. After five years, already 12.6 million farmers on 37 million hectares were taking part in transitions towards agricultural sustainability, with a top result – the mean relative yield increase was 79% across a very wide variety of systems and crop types (Report, 2006).

In the last half-century, there has been remarkable growth in agricultural production, mostly in developing countries. Since the beginning of the 1960s, aggregate world food production has grown by 145%. At the same time, the arable area has expanded by 10%, from 1.27 to 1.4 billion ha, and the total agricultural area has expanded by 11%, from 4.5 to 5 billion hectares. In developing countries, agricultural land area has risen by 21%, but in industrialised countries, it has fallen by 3%. During this period, the intensity of production on agricultural lands has also risen substantially. The area under irrigation and the number of agricultural machines have almost doubled, and the use of all fertilizers has increased four-fold (and of nitrogen fertilizers seven-fold). The use of pesticides in agriculture has also increased significantly, and now comes to 2.56 billion kg per year (Report, 2006).

Such an increase in material inputs leads to a surge in the volume of production, but it also has to have a severe impact on the environment. It is estimated that 30% to 80% of nitrogen supplied to the soil in fertilizers is lost to air or water due to incorrect agricultural practices. The same percentage of water is lost in irrigation systems because they are implemented incorrectly, resulting in over saturation of the soil on the one hand, or in excessive, non-effective water use on the other hand (Smil, 2001). These undesirable side effects have their costs called external costs, or simple negative externalities because they are external to markets and are not included in the

price and thus not paid by producers or consumers. They represent costs incurred by the whole society for the actions of farmers. Negative externalities are simply the costs of using the environment, either through the exploitation of natural resources as an input or by using the 'clean' environment as a sink for pollution (Pretty et al., 2001).

Negative externalities are one of the classic causes of market failure. To remove this deficiency, the costs should be borne by the polluter or, in other words, they should be "internalized". This is the 'polluter pays' principle, which was accepted by all the governments of the OECD in 1972 and later, in 1995, laid down in the Treaty of Rome (Conway and Pretty, 1991; Ekins, 1999). But, in many cases, internalizing costs (or benefits) is not feasible, especially if the true monetary values cannot be determined. A variety of legal, institutional and economic instruments, as well as their combinations, are available for achieving internalization (Buttel, 2003; Pretty et al., 2001). Among the most effective economic instruments are environmental taxes and charges, tradable permits and the targeted or coupled use of public subsidies and incentives. The compensation of external costs should be preceded by their accurate valuation, with the aim not to replace the free market but just to reduce some of its negative effects. In this way a compromise could be achieved between the best of self-regulation of the market and statutory regulations to ensure the agriculture will work in an efficient and environment-friendly manner.

The external costs of modern agriculture could be very different depending on its intensity and the countries involved. In the USA, for example, the total external costs in the year 1996 were $81 per hectare of arable land and permanent pastures, in Germany $112, but for the UK rising as high as $343 because that country's economy bore over two billion dollars in costs to handle the disease of bovine spongiform encephalopathy (BSE) (Pretty et al., 2001).

Agriculture, even when very intensive, produces not only negative externalities but also some positives. They include not only the obvious benefits like food, industrial raw materials (fibre, oil), but also those hardly ever transmitted through prices like accommodation and water supply, flood control and carbon sequestration, nutrient fixation, soil formation and even non-material ones, such as landscape and aesthetic value and biodiversity. The value of these external benefits is estimated on a per hectare basis to be $33 to $100 in the UK (Pretty et al., 2001). Much more social and environmental benefits is associated with organic farming. In the UK, organic agriculture produces $125-$200/ha of positive externalities each year (with particular benefits for soil health and wildlife) (Cobb et al., 1998). In addition to this, negative externalities of organic agriculture are far smaller than those of the conventional one.

The external benefits provided by organic agriculture for wildlife are very significant, particularly for animals so important to field ecosystems, like earthworms, bugs (true bugs), ground beetles (predatory), centipedes, spiders, mites, birds. The numbers of wild animals and beneficial organisms on the land under organic agricultural practices have exceeded those under conventional ones by a factor of two to seventeen (Pfiffner, 2001).

Extensive research on agro technical and economic aspects of organic and conventional fruit production in Poland has been undertaken within the EcoTechProduct Project titled: Development of innovative products and technologies for organic fruit production. T,his will greatly contribute to the development of innovative technologies and products for organic production in Poland and in Europe.

MATERIAL AND METHODS

In the year 2010, 518 527 hectares of agricultural land were managed organically in Poland. Conventional agriculture has deleterious effects on the environment and human health, which organic farming has not. To properly estimate non-monetary values of organic agriculture, the cost of negative externalities of conventional agriculture should be calculated, simply as a consequence of replacing one with the other (conversion to organic). In Poland, all organic farms are former conventional farms. To calculate the cost of negative externalities in Poland, a comparison with existing available data from Germany, the UK and the USA was made on the basis of the area of agricultural land (number of hectares), number of livestock, intensity of agricultural production and the tonnage of pesticides and fertilizers used in agriculture in those countries (according to the proportions of the polluters). Damages to water and soil quality were estimated on the basis of fertilizer and pesticide use. Costs of emission of greenhouse gases were calculated on the basis of the number of livestock. Losses to biodiversity and damages to health were calculated on a per hectare and production intensity basis. To estimate the value of positive externalities produced by organic farming in Poland, data from scientific reports were used (Cobb et al., 1998). The data concerning the facts on Polish agriculture (area of agricultural land, livestock, tonnage of pesticides and fertilizers used) were taken from the Central Statistical Office of Poland, from the Ministry of Agriculture and Rural Development and the Ministry of Environment. To accomplish the comparison of the data from different time periods and to adjust costs and prices to the year 2010, the retail price index from http://www.measuringworth.-com/ was used.

RESULTS

The comparative data on negative externalities in the USA, the UK, Germany and Poland are presented in Table 1. The total annual external

Table 1. Annual external costs of modern agriculture in the USA and some European countries in 2010 (in millions USD)*

ISO country code	US	GB	DE	PL
Damage to environment: water				
Cost of purifying drinking water to remove contaminants of agricultural origin (pesticide residues, nitrate, phosphate and soil particles, Cryptosporidium and other zoonoses)	3196.1	486.5	131.8	124.3
Eutrophication, pollution incidents, fish deaths, monitoring costs	386.4	38.6	75.0	61.3
Damage to environment: air				
Emissions of greenhouse gases (carbon dioxide, methane, ammonia, nitrous oxide)	24859.8	2530.1	2557.4	1644.8
Damage to environment: soil				
Erosion, blocked ditches and lost water storage (flooding), costs for industry, navigation and fisheries, organic matter losses and carbon dioxide release from soils	18303.8	218.2	-	262.7
Damage to environment: biodiversity and landscape				
Biodiversity/wildlife losses	495.6	56.8	9.1	20.5
Landscape losses (river banks, hedgerows and dry stone walls), domestic animals and bee colony losses	345.5	229.5	2.3	7.7
Damage to human health: pesticides, nitrate, micro-organisms/disease agents	200.0	2.3	20.5	13.6
Bacterial and viral outbreaks in food	-	384.2	-	-
Total annual external costs	47787.3	3946.3	2796.0	2134.8
Total annual external costs per hectare of arable land and grassland	111.4	350.3	161.4	129.4

Sources: adapted from Pretty et al., 2001; Pimentel et al., 1995; Fleischer and Waibel, 1998; Ribaudo et al., 1999 and authors' own studies

*Some cost items could be not sufficiently calculated because of the lack of adequate data (for example for Germany), thus could be not quite comparable with those from other countries

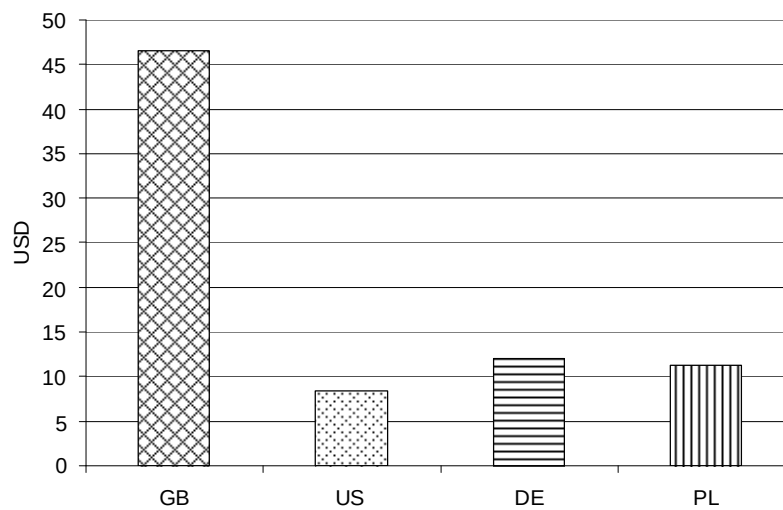
costs are the highest in the USA and the lowest in Poland, which is an obvious consequence of the size of the country and cultivated area. The biggest cost item in all the countries is the emission of greenhouse gases, which constitutes from 52% of the total costs in the USA to 91% for Germany. The share of emission in the total costs in Germany is surprisingly high because the other cost items could not be adequately calculated or were not available (Pretty et al., 2001).

The external costs of conventional agriculture in 2010 amounted to 111.4 USD per hectare of arable land and grassland in the USA, 129.4

USD in Poland, 161.4 USD in Germany and rising to 350.3 USD in the UK. These differences, however, may not be so great, owing to large gaps and uncertainties in the data.

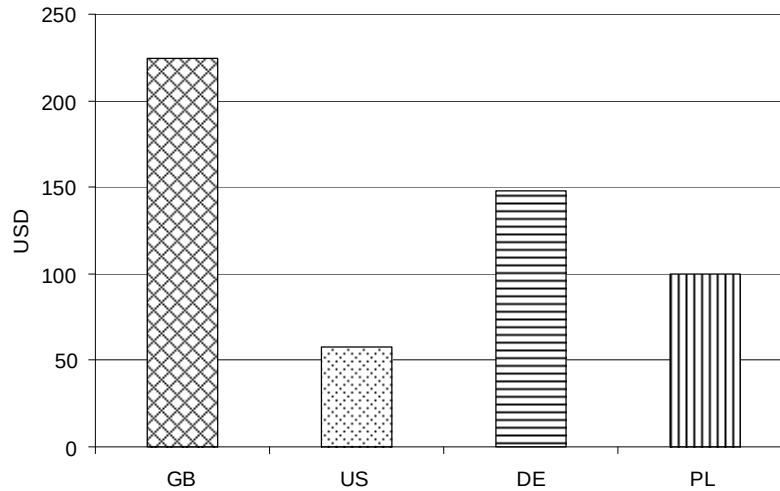
Pesticides, nutrients (nitrogen, phosphorus and potassium), soil, farm wastes and microorganisms leak from farms to pollute ground and surface water. Costs are incurred by water supply companies. These costs, as well as expenses incurred by other entities for restocking rivers with fish to restore them to their pristine condition, were the basis for the evaluation of the damage caused by agriculture to water quality. The annual costs of the damage to water quality caused by conventional agriculture on a per hectare basis were the highest in the United Kingdom – 46.64 USD/ha and the lowest in the USA – 8.35 USD/ha (Fig. 1). For Poland, they amounted to 11.25 USD per hectare, which was a little less than in Germany.

Agriculture emits to the atmosphere four gases: methane from livestock, carbon dioxide from fuel consumption and loss of soil carbon, ammonia from livestock wastes and fertilisers, and nitrous oxide from fertilisers. In this study, the annual costs of greenhouse gas emissions of agricultural origin amounted to 224.70 USD per hectare of agricultural land in the UK, 147.62 USD per hectare in Germany, 99.68 USD per hectare in Poland and 57.95 USD per hectare in the USA (Fig. 2). The differences between the countries were not so striking as in the case of water pollution.



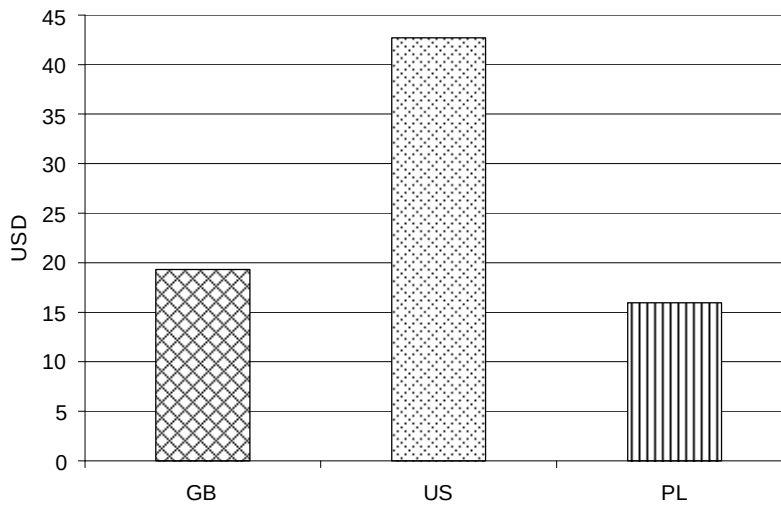
Sources: Pretty et al., 2001; Pimentel et al., 1995; Fleischer and Waibel, 1998; Ribaudo et al., 1999 and authors' own studies

Figure 1. Annual cost of damage to water quality by agents of agricultural origin, per hectare of agricultural land ($)



Sources: Pretty et al., 2001; Pimentel et al., 1995; Fleischer and Waibel, 1998; Ribaudo et al., 1999 and authors' own studies

Figure 2. Annual cost of damages caused by agricultural emissions of greenhouse gases, per hectare of agricultural land ($)



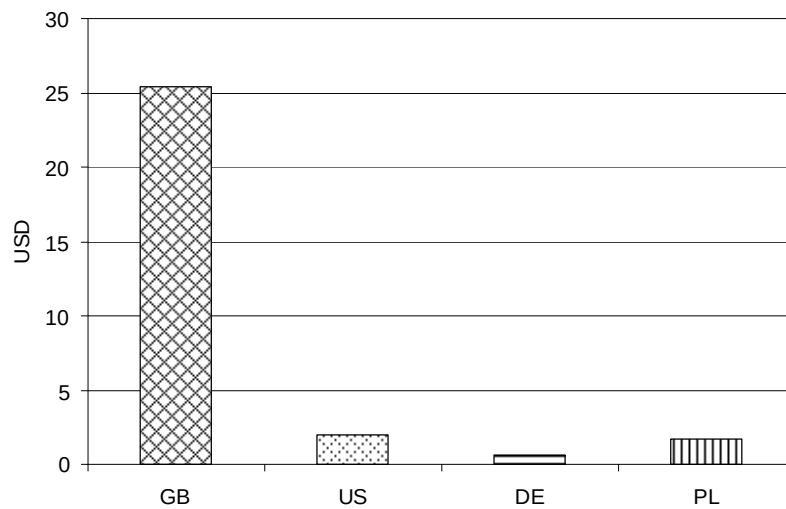
Sources: Pretty et al., 2001; Pimentel et al., 1995; Fleischer and Waibel, 1998; Ribaudo et al., 1999 and authors' own studies

Figure 3. Annual external cost related to soil losses, per hectare of agricultural land ($)

Annual external costs related to soil losses were as high as 42.66 USD per hectare of agricultural land in the USA, 19.38 USD per hectare in the UK and 15.92 USD per hectare in Poland (Fig. 3).

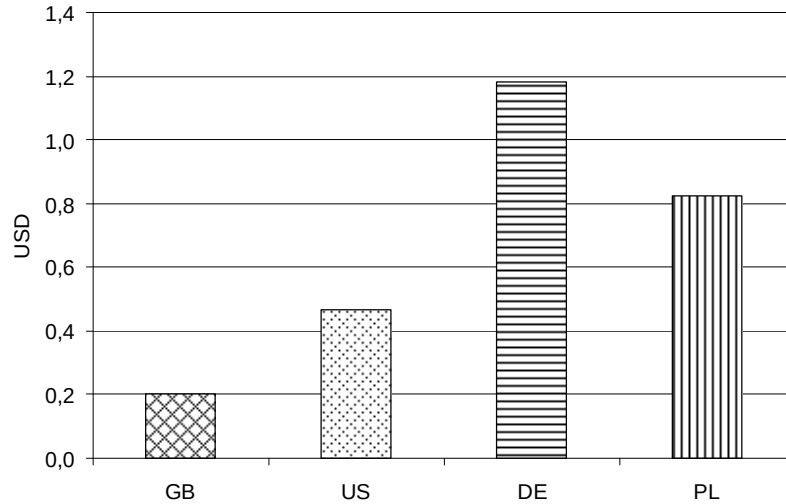
Annual costs of biodiversity, wildlife and domestic animal losses caused by agriculture worked out to 25.44 USD per hectare in the UK, 1.96 USD per hectare in the USA, 0.66 USD per hectare in Germany and 1.77 USD per hectare in Poland (Fig. 4) Annual costs related to human health problems caused by agriculture came to 0.20 USD per hectare in the UK, 0.47 USD per hectare in the USA, 1.18 USD in Germany and 0.82 in Poland (Fig. 5)

After adjusting the possible values of positive externalities produced by organic farming, obtained from Cobb et al. (1998), to the 2010 prices, we obtained a range from 166.4 USD per hectare to 266.2 USD per hectare. On the basis of the structure of Polish organic farming (ratio of the area of the more useful grassland and cereals to the rest of organic crops), the average weighted estimate was calculated as equal to 217.3 USD per hectare (Tab. 2). Then by multiplying the number of hectares under organic farming in Poland (518527) and the calculated values of positive externalities per hectare we obtained the total amount of positive externalities produced by organic farming in Poland. Thus the average weighted estimate of the total amount of positive externalities expressed in PLN was 339.8 million.



Sources: Pretty et al., 2001; Pimentel et al., 1995; Fleischer and Waibel, 1998; Ribaudo et al., 1999 and authors' own studies

Figure 4. Annual costs of biodiversity, wildlife and domestic animal losses caused by agriculture, per hectare of agricultural land ($)



Sources: Pretty et al., 2001; Pimentel et al., 1995; Fleischer and Waibel, 1998; Ribaudo et al., 1999 and authors' own studies

Figure 5. Annual costs related to human health problems caused by agriculture, per hectare of agricultural land ($)

Table 2. Combined beneficial effects of organic agriculture in Poland in the year 2010 as a sum of its non-monetary external benefits and the external costs which were offset by the transition from conventional to organic production

Specification	Conservative estimation	Progressive estimation	Medium estimation
Positive externalities of organic agriculture in USD per 1 ha	166.4	266.2	217.3
Positive externalities of organic agriculture in millions PLN	260.1	416.2	339.8
Negative externalities which were offset by the transition from conventional to organic production in millions PLN	174.2	252.4	202.3
Combined beneficial effects attributed to of organic agriculture in Poland in million PLN	434.3	668.6	542.1

Similarly, by multiplying the area of organic farming in Poland and the calculated values of negative externalities per hectare (129.4 USD) we obtained the total amount of external costs which were offset by the transition from conventional to organic production, expressed in PLN as the amount of 2023 million (2.023 billion). Finally, the combined beneficial effects attributed to organic agriculture in Poland, expressed as a sum

of its positive externalities and appropriate negative externalities as a result of switching to organic production, amounted to 542.1 million PLN within a range from 434.3 million PLN to 668.6 million PLN.

DISCUSSION

The results presented in this study – the estimates of the external costs of conventional agriculture in Poland as well as the estimates of the benefits of organic agriculture – are likely to be conservative for a variety of reasons. Some costs were not included or cannot be calculated, for example, the costs of restoring the environment or human health, the cost of marine eutrophication and the externalities arising from transporting food from farms through a chain of processing and marketing facilities to its final destination – the consumer. Some external costs are known to be substantial underestimates, like acute and chronic pesticide poisoning in humans, monitoring costs, eutrophication of reservoirs and restoration of biodiversity losses. While estimating the benefits of organic agriculture, this study underestimates how much people might be willing to pay to see more of the positive externalities created (Darling and Topp, 2000).

The annual costs of damage to water quality caused by conventional agriculture on a per hectare basis were the highest in the United Kingdom, four to five-fold higher than in the rest of the countries surveyed, but it does not mean that British agriculture pollutes water more than the German or Polish one. It is just that the data for the UK were collected more thoroughly. In that case, the values for the rest of countries could be underestimated.

In this study, the annual costs of greenhouse gases emissions of agricultural origin, were the highest in the UK, almost twice as high as in the next country on the list – Germany. According to the website (www.wordmapper.org) presenting the joint research project of the University of Sheffield and the University of Michigan devised by Danny Dorling and called "WORLDMAPPER", the emissions of US agriculture expressed as CO_2 equivalent were 467.4 million tons, the UK agriculture's greenhouse gases emissions amounted to 46.8 million tons, those of the German agriculture to 88.3 million tons and Poland's to 25.9 million tons. When calculated on a per hectare basis, the figures are respectively 4.2 tons per ha, 5.1 tons per ha, 1.6 tons per ha and 1.1 tons per ha. Thus the order in natural units is different from that presented in this study in monetary values.

The costs of soil erosion calculated in this study were, not surprisingly, the highest in USA. Pimentel et al. (1995) estimates, using an average erosion rate in the USA of 17 tons per ha per year on conventionally tilled land in corn, that the total on-site cost is 146 USD per hectare (the number of hectares under corn was 160 million) (Pimentel et al.,1995).

CONCLUSIONS

1. The negative externalities of conventional agriculture in Poland are still lower than those in more developed countries; however, because of the new rules for CO_2 emissions, they will become more significant in the future.
2. It is extremely difficult to count the externalities properly because of the large variety of reasons which may be taken into consideration, as well as the lack of official data on the losses caused by conventional agriculture.
3. The combined beneficial effects attributed to organic agriculture in Poland are worth more than 500 million PLN, while the losses attributed to conventional farming are worth at least 4 times as much.
4. Because of the lack of information concerning the externalities associated with conventional agriculture there is a great need to carry out more research on the subject.

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WSTĘPNA OCENA ODDZIAŁYWANIA NA ŚRODOWISKO NATURALNE ROLNICTWA EKOLOGICZNEGO I KONWENCJONALNEGO W POLSCE

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S T R E S Z C Z E N I E

Celem niniejszych badań była ocena zewnętrznych korzyści odnoszonych przez społeczeństwo z rolnictwa ekologicznego w Polsce. W roku 2010 powierzchnia upraw ekologicznych w Polsce wynosiła 518 527 ha. Oprócz bezpośrednich nierynkowych (zewnętrznych) korzyści uwzględniono również zmniejszenie strat spowodowanych zmianą sposobu gospodarowania na tej powierzchni z konwencjonalnego na ekologiczny, to jest zmniejszenie z tego tytułu obciążeń dla środowiska. Wyliczona w ten sposób suma łącznych korzyści odnoszonych przez społeczeństwo wynosiła ponad 500 mln złotych, podczas gdy obliczona według tych samych zasad wysokość kosztów zewnętrznych generowanych przez konwencjonalne rolnictwo w Polsce była ponad czterokrotnie wyższa.

Słowa kluczowe: rolnictwo ekologiczne, koszty zewnętrzne, korzyści zewnętrzne