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External Costs of Opencast Brown Coal Mining in Agriculture and Agri-Food Industry (on the Example of Wielkopolska)

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Abstract: The aim of the work was to analyse the external costs for agriculture and agri-food industry related to the possible launch of lignite deposits in Wielkopolska, that is, on the Ościsłowo, Dęby Szlacheckie and Oczkowice deposits. The duration of the mine's impact on the environment includes the period of drainage of the deposit, its exploitation and the time necessary for the reconstruction of water relations around the open pit. The level of losses in agricultural production was estimated based on the production results achieved by agriculture threatened by the occurrence of external costs based on the Central Statistical Office (CSO) data. The studies adopted two variants of the impact of open pitches on agriculture, including: the area of the estimated depression hopper, that is, the area in which the water table lowered by at least one meter and the entire impact area of the outcrop. In total, the external costs in agricultural production and processing, which may arise as a result of the launch of extraction from the three analysed deposits, were estimated at PLN 7.7–32.3 bn, losses in non-produced agricultural production at PLN 31.8–113.0 bn, while when the value of lignite is PLN 83.7–111.6 bn. Such high costs mean that the opening of new lignite deposits in Wielkopolska raises economic doubts. This also applies to each deposit separately.

Keywords: Opencast mine, external cost, plant production, animal production, agri-food industry

JEL Codes: O13, D24

1 Introduction

The quality of human life determines the availability of three resources: water and food, without which it cannot live, and energy, without which there are not many determinants of the quality of life such as electricity, communication, heat and production of goods. In connection with the depletion of coal resources in previously active opencasts, there are plans to launch new deposits. The mining environment is campaigning to convince the Polish society that new open pitches are necessary to secure the country's energy security. Acquisition of energy resources using the open-cast method, especially from the depth of several dozen meters or even over a hundred meters, however, requires drying the excavation, which causes losses in underground water resources, and through the occurring depression, it also has a negative impact on agricultural production. Such a dependence system causes a competition between lignite and water and food.

The growing prosperity, food waste and population growth means that by 2050 the demand for agricultural products is likely to double, with 30% of this growth being generated by biofuels (FAO 2009, 2, Clock 2012, 136). The demand for high-quality, animal and horticultural products will grow even faster; currently, in developing countries, 6–7% per annum (Clock 2013, 3, WB 2008, 12).

Already today, a serious barrier to production growth, not only in agriculture, is the shortage of fresh water. In many regions of the world, agriculture must compete for water with industry, processing, mining, and recently, also with water-intensive extraction of oil and gas from shale deposits. A serious warning is the situation in China, where within half a century, half the rivers have dried up, and the second largest river in China – the Yellow River – in 1997, it completely dried up for 9 months (Bloomberg 2013). The growing competition for water, which does not have a substitute, gives rise to increasingly stronger tensions threatening global order (Clock 2012, 174, GOS 2011, 58–59). Agriculture currently uses 66–70% of the total consumption of fresh water drawn from ground and underground as well as surface (flowing) resources, and in 2030, despite the increase in consumption, its share will fall to around 49% (Clock 2013, 4).

Energy consumption will also increase. In 2050, it may be higher by 30–80% depending on the improvement of energy efficiency (Al-Qahtani and others 2013, 152). It is also estimated that the share of renewable energy sources (RES) will increase from 9.3% in 2014 to over 20% in 2050 at the expense of fossil fuels, particularly coal (BP 2015,41, Al-Qahtania in 2013, 141; World Economic Forum 2015, 14). In Poland, the demand is expected to fall by 10–25% (MG 2014, 4, KIG ... 2012, 67).

In Poland, due to the depletion of lignite in active open-cast mines, the search for new decks, from which brown coal could be extracted, began. In Wielkopolska, the most advanced is the process of obtaining lignite from the Ościsłowo deposit, where the investor is awaiting the 'land regrowth' and the approval of the Environmental Impact Report and the Dęby Szlacheckie deposit, which are located in the Konin basin. Activities aimed at launching the 'Oczkowice' deposit in the southern Wielkopolska have also begun, which will result in the launch of a new coal basin in Poland. An investor trying to launch a new deposit is required to carry out the Environmental Impact Assessment and technical-economic analysis, which shows the economic calculation in microeconomic terms, that is not including external costs. Projects and analyses regarding future energy policy presented by the Ministry of Economy or the Prime Minister's Office completely ignore the problem of external costs (Wilczyński 2015, 34), as the valuation of the so-called free goods is a serious problem (Brown 2011, 183; Clock 2014, 57; Baum 2014, 76). Opencast coal exploitation and combustion involves the greatest external effects (economic, environmental and social) (Malicka 2014, 48); therefore, in this case, there is a need to trigger institutional and political factors that will create boundary conditions for the operation of the market mechanism, at which microeconomic competitiveness will be adjusted by the amount of external costs, which will be closest to the social and ecological optimum. Economic theory (neoclassical, mainstream) promotes excellent competition on the free market, which does not take into account external effects, which is unauthorized. It promotes private economic benefits, leaving to the public, nature and future generations, external costs in the form of exhausting non-renewable resources, environmental pollution and related to emissions of pollutants emitted by the power industry, which lead to an increase in the average temperature in the world. Such perception of economics leads to the emergence of global problems in the economic, ecological and socio-cultural dimensions (Clock 2013, 5, Czaja 2011, 42, Rogall 2010, 37).

The construction and operation of lignite in opencast mines causes, in the case of agriculture and agri-food processing, external costs such as:

- loss of profits related to the loss of harvest as a result of cessation of crop production in the area of outcrops and adjacent technical belts as a result of irretrievable and temporary exclusion from agricultural production of agriculture land located in this area. The entire farms will be liquidated along with their animal production.
- loss of profits resulting from the decrease in yields as a result of irreversible violation of water relations around the mine due to depression of the depression, deterioration of water relations and lower yields. Because in the area of depression, farmers will bear the same inputs in crop production but obtain lower yields, which is why the value of lost crops will almost simultaneously mean a drop in profits for them.
- loss of profits and costs of depreciation of buildings and equipment used in animal production, as well as lower use of own labour related to limiting livestock production through complete liquidation or reduction of this production in individual farms, due to reduction of arable land and decrease in yield (feed resources).
- decrease in profits obtained by the agri-food industry due to the limited scale of operations as a result of violation of their raw material base, which will affect dairies, meat plants and fruit and vegetable processing plants.

In connection with the above, the aim of the study is to analyse the external costs for agriculture and agri-food industry related to the possible launch of lignite deposits in Wielkopolska, that is, on the Ościsłowo, Dęby Szlacheckie and Oczkowice deposits.

In the study, due to the limitations of text volume, no other external costs are analysed, such as external costs for forestry, the natural environment, social costs, such as resettlement and related health consequences, loss of employment, loss of taxes [Kudełko 2013, 25]. The work also does not take up external benefits related to the creation of new jobs in the mine, power plants and external companies and related to the influx of people.

The time range of the analysis covers a different period for individual outcrops depending on the time of the planned exploitation and the time necessary to rebuild water conditions in the vicinity of a depleted deposit, which usually lasts as many years as the drainage is taking. In the case of the Ościsłowo open pit, it will be about 51 years, Dęby Szlacheckie about 45 years, and in the case of Oczkowice, about 100 years.

2 External Effects of Brown Coal Mining Using the Opencast Method

External effects are associated with every human activity. Prof. Arthur Pigou (Baum 2011, 84) introduced the concept of externalities to economic sciences. The emergence and development of the concept of sustainable and sustainable development is seen as an expression of compromise, between striving to continue socio-economic development and the need to seriously treat the natural and social limitations and determinants of this development to preserve the basis of life and development of both contemporary and future generations. In sustainable development, profit (at the microeconomic level) is no longer the only measure of effectiveness, because the importance of ensuring intra-generation and intergenerational justice has gained importance (Baum, Śleszyński 2008, 12, Borys 2011, 58). The concept of real enrichment has also changed, by which one means to multiply one type of wealth that does not take place at the expense of others. The richness of the nation consists of, inter alia, natural wealth and indirectly the richness of nature, anthropogenic material and financial wealth, physical and intellectual human wealth as well as social, cultural and institutional richness (Poskrobko 2011, 9). Therefore, taking into account external effects, especially in large projects interfering with the environment is of key importance for achieving long-term social and ecological goals.

The construction and exploitation of lignite from new outcrops, especially in regions where opencast lignite mining has not been conducted up to now, has a number of external (positive and negative) effects in the economic, ecological and socio-cultural dimensions. In the case of new outcrops located near the fields already exploited, we are dealing with a lower intensity of external effects, because most of the external effects arose as a result of exploiting the first open pit, while the subsequent ones widen the area of influence and prolong their occurrence.

The construction and exploitation of the open pit creates new or preserve the existing workplace (also at the cooperating companies), which positively affects not only the local labour market, but also the local demand for goods and services. Exploitation of lignite is also associated with the payment of an operating fee to municipalities in the area of exploitation, which significantly increase the investment possibilities of communes. Unfortunately, these fees are obtained temporarily, that is, only during the course of extraction in a given commune. The exploitation of new deposits also secures cheap (but without taking into account external effects) energy resources that increase Poland's security and energy independence. As a result of the reclamation of post-mining sites, new recreational areas for the local community are also being created.

External costs result mainly from the fact that the opencast lignite exploitation requires removing at least a few dozen meters of overburden and the need to dry the deposit. As a result, the landscape is significantly changed, including in the form of a high external dump, depressions and flooded end excavation. Multi-year drainage of the deposit causes violation of water conditions in the quaternary and tertiary aquifers, which is manifested by the occurrence of depression funnels around the bed with a radius of up to several kilometres and change of pressure under the bed and in the dehydration area, which activates the ascension of waters from deeper aquifers that are often much saline. These changes lead to drying or lowering the water level in wells within a radius of several kilometres and lowering the level of groundwater and drying out small watercourses, which causes a drop in agricultural yields and losses in forestry, particularly severe near the excavation in dry years. The danger of contaminating underground freshwater resources is also growing. Changes in the water conditions also cause the depletion of fauna and flora not only in post-mining areas, where after reclamation is particularly poor, but also in the area affected by dehydration. Launching the outcrop is also connected with the necessity of gradually displacing inhabitants (mainly villages) from the area of the open pit and external dumps, who lose their property and work. Monuments, nature monuments and natural communities that are unique on the local and regional scale are also destroyed. Many middle-aged and older people, mainly farmers, who are often strongly attached to their fatherhood, will have problems with retraining and finding a job in a new environment. This will entail a deterioration of health, the need to pay benefits and so on. With the need to look for a new job must also count those who work on the site of the planned open pit and heap, because these plants may also cease to exist. An important external effect that worsens the quality of life of residents living near the excavation is the noise, dust and air pollution generated 24 hours a day, generated during the mining and production of energy.

3 Characteristics and Hydrogeological Conditions of the Ościsłowo, Dęby Szlacheckie and Oczkowice Deposits

3.1 Ościsłowo Deposit

The Ościsłowo deposit is located in the Koniński poviat and lies 1.5 km north of the currently exploited open pit Jóźwin IIB (Fig. 1). It has industrial resources of 39 million tons of coal located on average under 50.5 m of overburden. The excavation will occupy about 1580 ha in the communes of Wilczyn (51%), Ślesin (36%) and Skulsk (13%), of which 1177 ha constitute agricultural land (AL).

Because there are hydraulic connections between the Ościsłowo, Jóźwin IIB and open pit Kazimierz deposits through the Tertiary-Cretaceous aquifer, the range of depression funnels on these outcrops largely overlaps, thus limiting the area of influence (compared to the outcrop in the 'new' site) of hydrological as well as on the surface, that is, in agriculture, forestry and the broadly understood environment. The maximum range of impact of the Ościsłowo open pit in the Quaternary level is 91 km^2, that is, 6695 ha AL, and in the Tertiary-Cretaceous level 242 km^2, that is, 11429 ha AL. Within the boundaries of the designed Ościsłowo open pit and within the reach of the depression funnel, both the Quaternary and Tertiary – Cretaceous sediments include the soil II, III and IV of the bonitation class and grassland on organic soils, which constitute about 20% of the planned outcrop. So these are some of the best lands found for plant production in the Koniński poviat. The area of the common area of the depression funnel in the Quaternary level jointly for open pit Jóźwin IIB, Kazimierz and Ościsłowo was estimated at 136–174 km^2, and in the tertiary-chalk level at 330–382 km^2 (Brusiło and others 2015, 179–184).

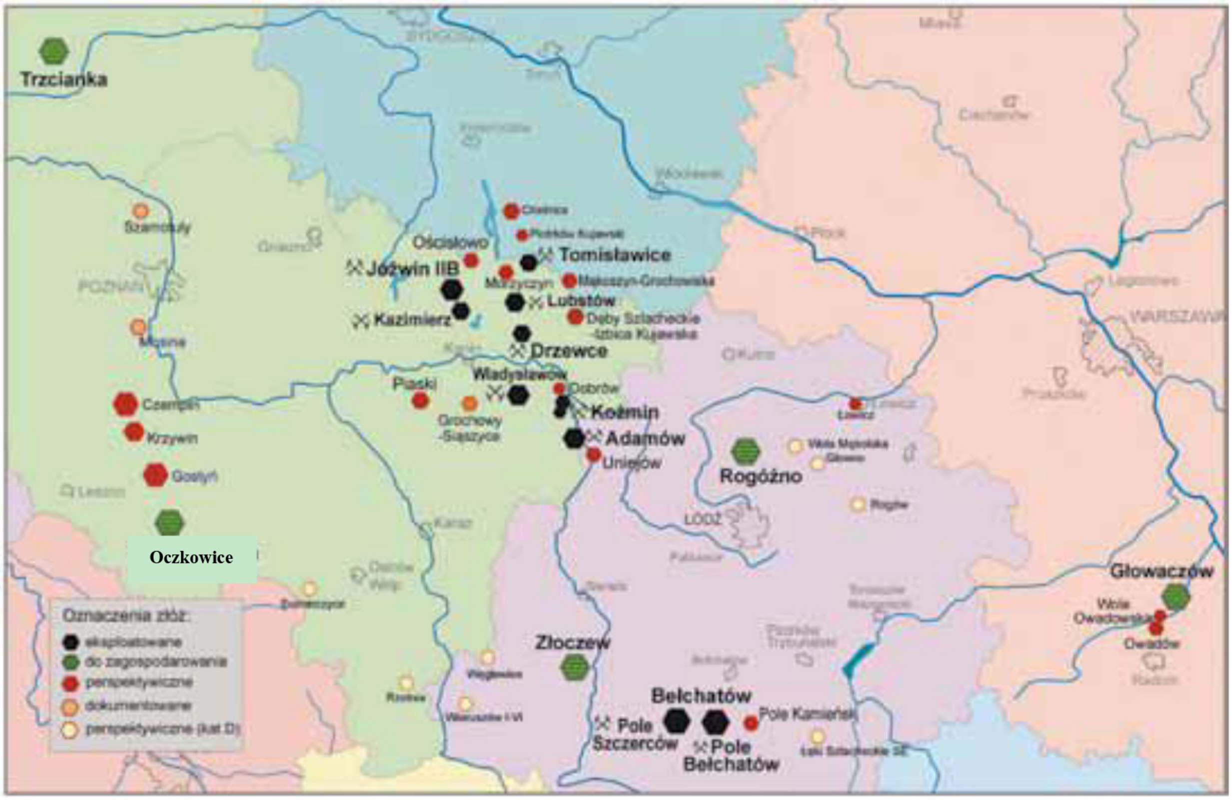


Fig. 1. Lignite deposits of the mining and energetic region of Adamów, Konin and Bełchatów
Source: Kasztelewicz, Sikora and Zajączkowski 2014, 40.

Model research has shown that drainage of Ościsłowo open-pit, operating in 2016 ÷ 2034 (at the time of writing, it is known that the start of dewatering process will be delayed by several years – author's footnote), will stop the process of natural filling of the excavation tanks of the openings: Kazimierz and Jóźwin IIB open-pit. After the drainage of the open-pit in Ościsłowo, it is around 2034, that all water tanks will be filled with water and a joint depression process will be open-pit, all open-pit in this area will be depleted. Model tests have shown that this will take place around 2066, which is about 32 years after the completion of the open-pit of Ościsłowo (Brusiło *et al.* 2015, 472–481).

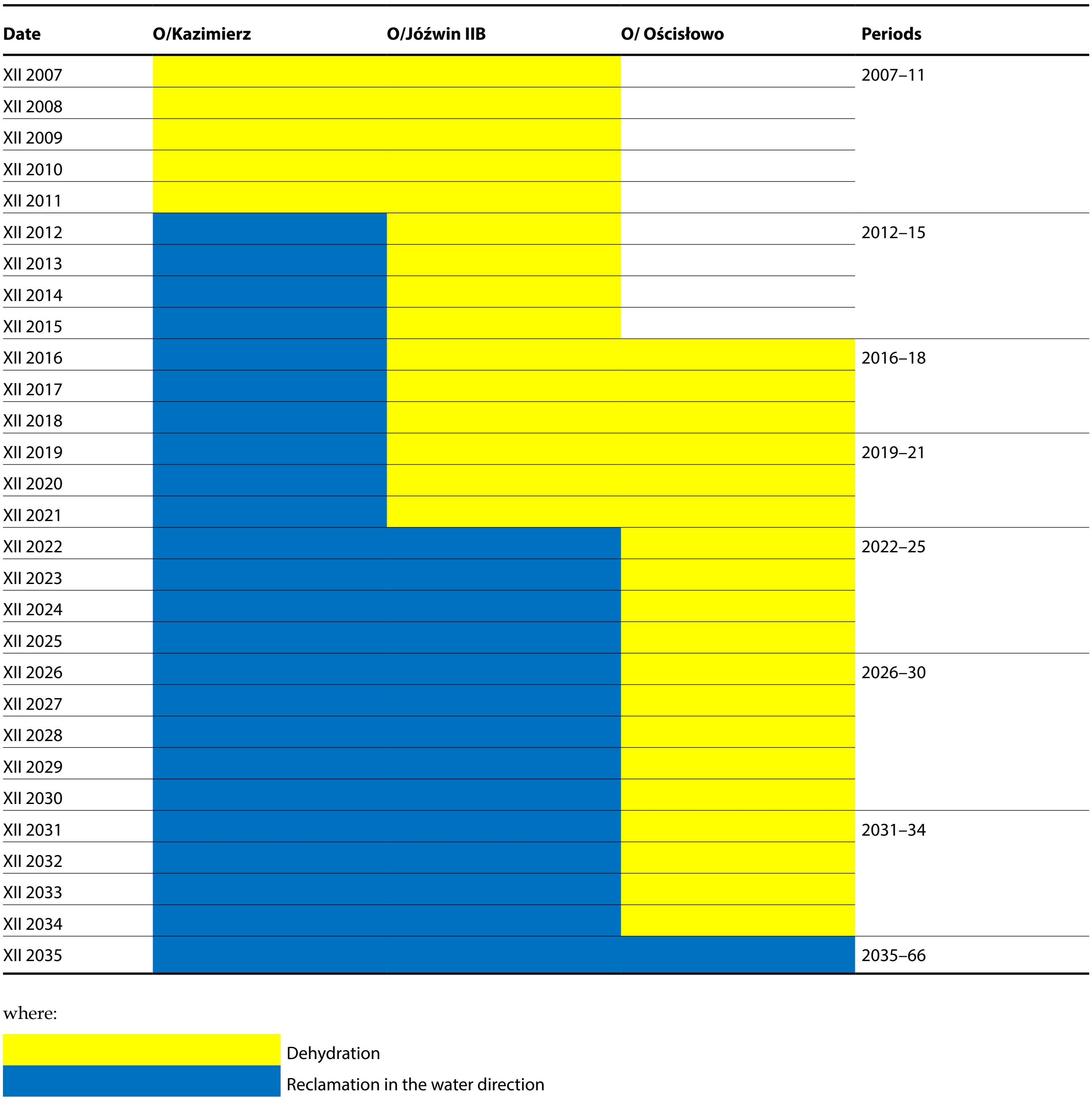
Tab. 1 shows that the original drainage of the Ościsłowo open pit will be completed 13 years later than the excavations of Jóźwin IIB and 23 years later than the excavations of Kazimierz. In connection with the above, due to the launch of the Ościsłowo open pit, the process of rebuilding water relations in the area of depression Jóźwin IIB and Kazimierz will be delayed by at least 15 years, and during this period, additional losses will be generated in agricultural and forestry production, which would not occur in the case of not launching the Ościsłowo mine. In connection with the above, in the calculation of external costs in the area of the depression funnel common to open pit Ościsłowo, Jóźwin IIB and Kazimierz, a period of 15 years and an average area of a common hopper of depression were adopted:

- 157.8 km^2, that is, 15780 ha for a depression of a Quaternary aquifer
- 355.6 km^2, that is, 35560 ha for a depression of a Tertiary depleted aquifer

However, in the case of losses caused exclusively by the Ościsłowo open pit, a period of 51 years was assumed, that is, 19 years of dewatering and 32 years of reconstruction of the water surface. Because the extent of the depression funnel changes along with the progress of extraction and after extraction, 60% of the maximum range of the depression of the quaternary and tertiary aquifer has been assumed in the analysis of the level of losses, that is:

- 54.72 km^2, that is, 5472 ha for the depression of the Quaternary aquifer
- 145.2 km^2, that is, 14520 ha for a depression of a Tertiary depleted aquifer.

Tab. 1. Anticipated schedule for the development of mining operation and drainage system in the area of the designed Ościsłowo open-pit



Source: Brusiło *et al.* 2015, 473.

3.2 The Dęby Szlacheckie Deposit

The Dęby Szlacheckie deposit is located in the Kolski poviat around 10 km west of the Drzewce open-pit mining plant (the planned end of operation is 2019) and about 25 km southwest of the Tomisławice open pit, where coal is to be mined until around 2030 (Kasztelewicz, Sikora and Zajączkowski 2014, 42). Industrial resources amount to 77 million tons and require the launch of an outcrop together with a belt of technical infrastructure with an area of 1500 ha (1230 ha AL) and removing with an average of 71.6 m overburden. It will also be necessary to occupy about 300 ha (267 ha of AL) for the planned external dump. Most of the Dęby Szlacheckie open-pit area is located within the territory of the Babiak commune, the remaining part within the Koło commune. In the area of opencast, agricultural land constitutes about 82% of the area, largely in classes II and III, which is much better than the average in the former Konińskie Voivodeship, while in the external dump area AL constitutes about 89% (Wilczyński 2016, 17).

The location of the Dęby Szlacheckie deposit near the already exploited Drzewce open-pit, about 10 km away, makes that if both opencasts were operated at the same time, the western part of the depression funnel for the Dęby Szlacheckie mine would connect with the eastern part of the Drzewce depression funnel. However, since the Dęby Szlacheckie mine will be started probably after the extraction in the Drzewce opencast, the scope of the joint depression funnel will be limited in time to several years. In the case of the Tomisławice pit, it is unlikely that depressions will be connected to these pits due to the distance of about 25 km between these pits. From the information card for the Dęby Szlacheckie open-pit, it appears that the forecasted depression hopper will cover the area of 696 km^2.

3.3 The Oczkowice Deposit

The Oczkowice lignite deposit with the resources of 996 million tons is located in the Gostyński and Rawicki poviats. Brown coal lies at a depth of 111 to 134 m.p.p. The thickness of the coal seam is between 11 and 14 meters (Przybyłek 2015). Unfortunately, unlike the two previous deposits, which are located in the tertiary levels of freshwater, the Oczkowice deposit is located in the region with a complex geological structure resulting, inter alia, from the existence of deep tectonic trenches (Deczkowski and Gajewska 1980, 152, Widera 2007), as well as the occurrence of highly mineralized groundwater under coal seams (Łaszcz-Filakowa 1978, 29–127, Przybyłek 1986, 146, Przybyłek and Górski 2016, 185), which favours the migration of these waters (Bojarski 1996).

Due to the fact that in 2018, the mine exploitation project was not yet developed, in this report, the basis for calculating external costs for agriculture in the area of a potential opencast is the deposit development concept presented by Kasztelewicz, Sikora and Zajączkowski (2012, 140–144), which assumes that the outcrop will cover 5855 ha, of which 5324 ha is AL. In addition, 574 ha, mainly AL, is to be allocated to the external dump.

Dehydration of the aquifer also in the case of this discovery will result in the creation of a deep and extensive depression funnel, which according to Dąbrowski *et al.* (2015) and Przybyłek and Górski (2016, 190) will reach at least 3–5 km from the bed boundaries, and up to 10 km along the course of fossil valleys, and the depression funnel will reach sizes many times larger than the area of the documented brown coal deposit (radius of up to 20–25 km). Assuming a drainage funnel with an area of 300 km^2 and a 75% share of AL, the area of AL affected by the effect of a drying hopper will amount to about 22,500 ha of AL. The share of agricultural land in the area of the planned excavation in the structure of land is higher (91%), which proves the highly agricultural nature of the Gostyński and Rawicki poviats. In addition, agricultural land in the Miejska Górka municipality is characterized by the best soils in the Rawicki poviat (Board of Rawicz District 2008, 14), and the Krobia commune has the best soil in Wielkopolska (50% of land classified as Class II and IIIa) (UMiG Krobia 2008, 8).

The location of deposits, which are located in the regions with the lowest precipitation in Poland, is also of great importance for agriculture and potential losses in plant production.

3.4 Characteristics of Agriculture in the Area of the Analysed Deposits Koniński and Kolski Poviats

The impact of each open pit extends well beyond the excavation site, and in the opinion of many experts, beyond the estimated depression of tertiary aquifer. It is reasonable to know the importance and scale of agriculture not only in Kolski and Koniński poviats, but also in the southern districts of the Kujawsko-Pomorskie Voivodeship, Ościsłowo and Dęby Szlacheckie open-air mines will be active. There are 71.6 thousand ha of AL in the Kolski poviat and 92.2 thous. ha AL in the Koniński poviat, accounting for nearly 1.1% of AL in Poland and 9.2% of AL in the Wielkopolskie voivodship (Tab. 2). The share of agricultural land is significantly higher than the average in Poland, and in the case of the Kolski poviat higher than in the Wielkopolskie voivodeship and amounts to 70.82%. The analysed poviats are characterized by a higher concentration of cattle and cow population than in Poland and Wielkopolska, which in the case of the Kolski poviat is about 70% higher than the average in Poland and respectively by 33% and 70% higher than in the Wielkopolska voivodship. In contrast, the pig population is significantly lower in the Kolski poviat than the average in Poland (by about 15–30%), but

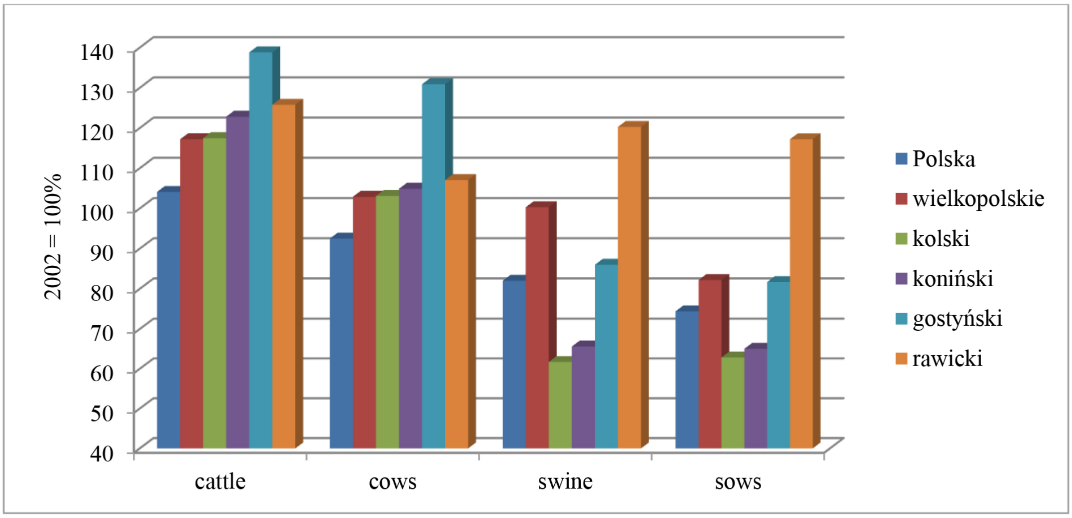


Fig. 2. Changes in the population in the Kolski, Koniński, Gostyński and Rawicki poviats against the background of Poland and the Wielkopolskie voivodships in the years 2002–2010

Source: Universal agricultural census 2010. Central Statistical Office Poznań 2012; Report on the results of censuses 2002. Wielkopolskie Voivodeship. CSO, Poznań 2003.

Tab. 2. Characteristics of Kolski, Koniński, Gostyński and Rawicki poviats against the background of the Wielkopolskie Voivodeship and Poland in 2010

Specification	Participation UR (%)	Area UR (ha)	The number of animals (pcs)				Stocking of animals (pcs / 100 ha UR)			
			cattle	cows	swine	sows	cattle	cows	swine	sows
Polska	49.58	15502969	5760585	2657365	15278051	1426575	37.2	17.1	98.5	9.2
wielkopolskie	60.01	1789875	844289	304467	4819561	383753	47.2	17.0	269.3	21.4
kolski	70.82	71598	45132	21237	48167	5547	63.0	29.7	67.3	7.7
koniński	58.39	92186	48144	18492	95921	9410	52.2	20.1	104.1	10.2
gostyński	77.27	62608	59562	25288	255776	22551	95.1	40.4	408.5	36.0
rawicki	76.60	42400	40682	12206	223360	21195	95.9	28.8	526.8	50.0

Source: Characteristics of farms in the Greater Poland Voivodeship. Universal agricultural census. CSO Poznań 2012.

by 64–75% lower than the average in the Wielkopolskie voivodship, and in the Koniński poviat by 6–10% higher than in Poland, but 50–60% lower than in Wielkopolska.

Trends that take place in the animal stock are also important (Fig. 2). In the case of cattle, they are positive, as the stock of cows and cattle in general in 2002–2010 grew faster in the Kolski poviat than in Poland, but similar to the Wielkopolskie voivodship, while in the Koniński poviat the changes in the population were a few percentage points lower than in the Kolski poviat. On the other hand, negative trends are visible in pigs and sows, whose population decreased by 37–42%, while in Poland, the decline in livestock amounted to 18% and 25% respectively, whereas in the Wielkopolskie voivodeship in the case of pigs, there was stagnation and the number of sows fell by 18%.

3.5 Gostyński and Rawicki Poviats

Farms from the Gostyński and Rawicki poviats are characterized by a very high concentration of animal production, as the cattle population is more than twice as high as the average in Poland and Wielkopolska, and in 2010, in the Gostyński poviat, these amounted to 103.66 pcs. * ha^{-1}. In the case of cows, it was about 70%

more, and in the Gostyński poviat, by 135% more. In the case of pigs and sows, disproportions in relation to the national average was even higher, because the stocking density was 4–5 times higher than the average in Poland and 70–130% higher than the average in Wielkopolska (Tab. 2). The changes in the animal population was also favourable (Fig. 2). The cattle population in 2002–2010 increased more than on average in Poland and Wielkopolska by 10–20 percentage points. In the case of cows in the Rawicki poviat, similar to the other analysed regions, their population changed slightly; while in the Gostyński poviat, it increased by 30.9%. In the case of pigs, the analysed region was characterized by a smaller drop in the population than the average in Poland. In this case Rawicki poviat particularly stands out, where the number of pigs and sows increased respectively by 20.3% and 17.2%.

In summary, it can be stated that the production of pigs collapsed in the Kolski and Koniński poviats, while the cattle population grew slightly slower than in the Gostyński and Rawicki poviats. One of the most important reasons may be the weaker economic condition of pig farms, which in the period of low profitability of fatteners production and smaller direct surplus arising in crop production (caused by losses in crop production, associated with lower yields due to the occurrence of depression and deterioration of water relations in soil) forcing many farmers to stop this animal production.

4 Methodical Assumptions

The amount of external costs of starting the pit for plant production was calculated from the formula:

$K_r = \sum A*P*S*C*R/100$,

where:

K_r – costs in crop production (PLN),

A– area of cultivation of a given plant (ha),

P – crop ($t*h^{-1}$),

S – level of losses (%),

C – purchase price ($PLN*t^{-1}$),

R – profitability (%).

The process of lignite mining causes gradual taking of land for opencast. In the case of the Oczkowice open pit, within 50 years of mine operation, approximately 60% of this area will be excluded on average. Most of these areas will be lost forever for agriculture, because in the post-mining areas, as a result of reclamation of excavations, mainly dominate forests and recreational areas (Kasztelewicz, Ptak 2011, 166, Kasztelewicz, Sypniowski 2011, 297–300, Gilewska, Otremba 2013, 62). Recultivated land often differ significantly from soils naturally shaped by many properties such as lack of accumulation level, poverty of nutrients and yield instability (Gruszczyński 2010, 120). Therefore, in the calculations for all outcrops, it was assumed that losses in plant and livestock production from the area of open pit during the extraction period and during the reconstruction of water relations will amount to 60%.

Losses in livestock were calculated in proportion to the share of outcrops in the AL area of the poviats analysed. It was assumed that one piece of cattle (without cows) receives 300 kg of live cattle annually, and 180 kg of live pigs per pig. In the case of dairy milk yield and sow fertility, the average for voivodships was adopted, which amounted to 5837 litres of milk for cows in the Wielkopolskie voivodship and 5677 litres of milk in the Kujawsko-Pomorskie Voivodeship (CSO 2015a), and one sow respectively 19.5 and 18.3 piglets (CSO 2015b).

Calculation of losses around the open pit is much more difficult, as it is difficult to estimate: the development of depression funnels, the impact of lower groundwater levels on crop yields, soil and soil profiles' diversity, inputs and investments of farms for crop production. In the case of animal production, losses in production will be related to the abandonment or reduction of livestock, which will result from smaller feed resources (dependence on feed in cattle production is almost full, and in pig production, it reaches about 50% (Pepliński, Wajszczuk and Wielicki 2004, 114). As a result of the deterioration of the profitability of crop production, the smaller agricultural production also means lower turnover of the agri-food industry and suppliers of agricultural production resources from these regions.

In the first calculation variant, external agricultural costs were calculated for the areas of the estimated third and quaternary depression funnels. In the case of the Ościsłowo deposit, due to its proximity to the currently exploited Józwin IIB deposit, it is necessary to distinguish its own depression hopper for the Ościsłowo deposit, which was estimated at 199.2 km^2. With approximately 58.4%, the share of agricultural land in the total area of the Koniński poviat, it gives about 11674 ha AL and a funnel of a joint 513.4 km^2, that is around 29979 ha AL (Brusiło 2015, 475). In the case of the Dęby Szlacheckie deposit, the area of the estimated depression funnel is 696 km^2, that is, 47141 ha of AL located in the Kolski, Koniński, Radziejowski and Włocławski poviats (the last

Tab. 3. The level of yields in the present Wielkopolska province (without the former Konińskie voivodship) and the former Konin Voivodeship in the years 1956–1990 (t * ha^{-1})

Specification	wielkopolskie	konińskie	wielkopolskie = 100%
1956–1960	1,685	1,572	93.35
1961–1965	1,996	1,866	93.49
1966–1970	1,861	1,693	90.98
1976–1980	2,796	2,347	83.95
1981–1985	3,146	2,590	82.33
1986–1990	3,448	2,650	76.85

Source: Own calculations based on data from the CSO statistical yearbooks from 1957–1991.

two are located in the Kujawsko-Pomorskie Voivodeship) (Wilczyński 2016, 22). For the Oczkowice deposit, it was estimated at about 300 km^2, which, with a 75% share of agricultural land, gives a total area of 22500 ha AL (Dąbrowski and others 2015, Przybyłek and Górski 2016, 190).

However, the area of impact of the mine is much larger, because the area of the depression funnel covers the area where the water table as a result of dehydration has dropped by at least one meter. For plants, especially meadows and pastures, long-lasting, even small, lowering of the water table significantly affects yields (Malewski 2011, 91). Therefore, a wider range of impacts of the outcrops was determined (option II). The starting point for defining the area of impact and external costs in plant and animal production were the production results in the former Konińskie Voivodeship compared to the production results in the remaining part of the Wielkopolskie voivodship (until 1975 – Poznańskie Voivodship) in 1956–1970 and 1976–1990 (Tab. 3). In the years 1956–1965, when the coal basin near Konin was only being built on the area of the former Konińskie Voivodeship, yields were only 6.65% lower than the average in the then Poznań voivodship, while in the years 1986–1990, they were already at 23.15 % lower, and compared to 1981–1985, there was a decrease in the relative height of yield by almost 5.5 percentage points, which suggests that the relative decline in yields could continue. It should also be assumed that in the immediate vicinity of outcrops, the yield losses are even higher. In the entire province of Konin, around 5 outcrops in the vicinity of Konin and Turek were active throughout the above period; therefore, for individual pits, the impact zone that was correspondingly smaller in the second variant was adopted. For the Ościsłowo open-pit, 118095 ha of AL was assumed, that is, about 33% of the AL of the former Konińskie voivodship (50% of the Koniński poviat, 66% of Mogileński poviat, 50% Radziejowski poviat and 17% of Inowrocławski poviat). For the Dęby Szlacheckie open-pit, 131,051 ha of AL, which represents about 36% of AL area in the former Konińskie Voivodeship (66% of Kolski poviat, 20% Koniński and poviats from Kujawsko-Pomorskie voivodship, that is, 33% of Włocławski poviat, 50% Radziejowski poviat and after 10% of Inowrocławski and Mogileński poviats). For the Oczkowice deposit, the area of impact will be the largest and will amount to about 260,000 ha of AL, which is about 66% of AL area in the former Konińskie Voivodeship (the whole area of Gostyński and Rawicki poviats and two thirds of neighboring poviats from the Wielkopolskie Voivodeship, i.e., Jarociński, Kościański, Krotoszyński, Leszczyński and Śremski poviats).

For the impact area under option II, it was assumed that the yield decrease associated with the commissioning of outcrops would be on average 17.7%, that is, as much as the relative decrease in yields in the former Konińskie voivodship in relation to yields in the remaining area of the Wielkopolskie Voivodship. In option I, it was assumed that it will be higher by 42% and will amount to an average of 25%.

The sowing structure was determined based on the data from the general agricultural census of 2010 (CSO 2012). The yield level was established on the basis of average yields from 2011–2015. For the Dęby Szlacheckie and Ościsłowo deposits for AL located in the Koniński poviat, yields were assumed to be lower than the average in the Wielkopolskie voivodship by 19.2%, and in Kolski poviat, due to better quality soils, 10% lower than the average in the Wielkopolskie voivodship. Because the deposits are located near the Kujawsko-Pomorskie Voivodship, the area of impact also includes poviats

Tab. 4. Concentration of the population on the territory of the present Wielkopolskie Voivodeship (excluding former Konińskie voivodship) and the former Konin Voivodeship in the years 1959–2010 (pcs * 100ha^{-1})

Specification	wielkopolskie				konińskie				wielkopolskie = 100%			
	cattle	cows	swine	sows	cattle	cows	swine	sows	cattle	cows	swine	sows
1959	43.64	30.28	72.79	8.60	39.16	28.78	68.35	8.82	89.73	95.03	93.91	102.63
1965	52.32	28.26	102.18	11.08	43.60	27.43	90.98	11.61	83.35	97.07	89.04	104.79
1975	71.32	29.47	155.92	14.54	74.90	29.40	89.56	10.56	105.02	99.76	57.44	72.60
1985	59.23	26.75	153.25	15.38	58.16	28.54	82.96	10.33	98.19	106.70	54.14	67.14
1996	44.22	16.79	252.15	23.40	45.11	21.12	118.85	12.02	102.02	125.74	47.13	51.36
2002	38.91	15.45	285.65	27.55	43.38	20.66	148.78	15.56	111.48	133.72	52.09	56.51
2010	46.08	16.18	299.89	23.46	53.27	21.67	97.60	10.12	115.61	133.94	32.54	43.14

Source: Own calculations based on CSO data.

from this voivodship, and therefore, for AL located in this area, average yields from this voivodship were adopted. In the case of Oczkowice deposit, based on data from the CSO statistical years 1976–1990, yields in the Leszczyński poviat were on average 15% higher than the average in the present Wielkopolskie Voivodeship; therefore, this level of yields was adopted for the second variant of calculations. Because the Oczkowice deposit is located in poviats with the highest quality agricultural land, it was conservatively assumed that the yields on the area of the outcrop and for the first variant of calculations are 30% higher than the average in the Wielkopolskie voivodship. Purchase prices for cereals, rape, sugar beet, beef, pig and piglets were calculated on the basis of average purchase prices of basic agricultural products in the Wielkopolskie and Kujawsko-Pomorskie voivodships in 2012–2016, respectively. The value of the remaining production was calculated according to the proportion resulting from the share of these plants in the structure of sowing in relation to the share of cereals, rape and sugar beet and their value.

In the case of animal production, it was observed in the former Konińskie Voivodeship that in the years 1959–2010, the concentration of pigs and sows increased by 43% and 15% respectively, cattle by 36% and the concentration of cattle population decreased by 25%; while for the entire Wielkopolska (without the former Konińskie Voivodeship), it was respectively 312%, 173% and 5% increase, and in the case of cows, the fall of the population by 46% (Tab. 4). After converting to Large Converting Units (LCU is a conversion art weighing 500 kg) in the analysed period, the population in the former Koniński voivodship increased by 20%, while in the whole Wielkopolskie voivodship (without the former Konińskie voivodship) by 47%, which gives a lower relative concentration increase livestock by 22.5%, or 4.8 percentage points more than in crop production. Because in animal production, there is a possibility of increasing the forage area and due to the progressive concentration of production, it was assumed that the decline in the population due to the launch of subsequent pits will be smaller. It was assumed that the population of cattle and cows would fall in the optimistic scenario by 20% in the area of estimated depression funnels (option I) and 15% in option II, and in the case of pigs – 12.5% and 9% respectively. However, it cannot be ruled out that the decline in livestock will be greater, as the profitability of animal production as a result of gaping price scissors decreases; therefore, any drop in profitability caused directly or indirectly by mining activity may increase the level of abandonment of animal production. It was assumed that the profit from animal production increased by depreciation costs and labour costs constitute about 25% of the value of animal production (Pepliński, Wajszczuk and Wielicki 2004, 110).

Estimating the costs of starting the outcrops for animal production was calculated from the formula:

$K_z = \sum Po*W*S*C*R/100$,

where:

K_z – costs in animal production (PLN),

P_o – herds (pcs),

W – performance or production (l, pcs, kg * pcs^{-1}),

C – purchase price (PLN * l^{-1}, PLN * pcs^{-1}, PLN * kg^{-1}),

R – profitability of production increased by% share of depreciation and labour costs in animal production costs.

External costs for the agri-food industry will be a decrease in profits caused by a reduced supply of agricultural raw materials. It was assumed that the share of agricultural raw materials in the value of sales of the agri-food industry is about 50%, and processing is responsible for 80% of pig and beef cattle and milk production (IERiGŻ 2015a, IERiGŻ 2015b). The average profitability of turnover in this industry is 3.5% (CSO 2014). For plant production, the average value of purchase of plant products in the years 2011–2015 was assumed as the base value, which amounted to PLN 1642.8*ha AL^{-1} for the Wielkopolskie Voivodeship, and PLN 1737.8*ha AL^{-1} for the Kujawsko-Pomorskie Voivodeship (CSO 2012–2016).

5 External Costs of the Possible Construction of Open-Pit Mines in Wielkopolska

Losses in the form of unrealized plant production in the Ościsłowo open pit were estimated at PLN 1.87 million annually, of which almost 50% are cereals, which will translate into a non-profit by farmers from this area at the level of PLN 0.47 million annually. In animal production, production losses are slightly higher and will amount to PLN 2.32 million annually, of which PLN 0.48 million will mean a loss in profits. Over the 51 years of the operation of the outcrop in its area, agricultural production of PLN 213.6 million will not be created, which will result in external costs in the form of an unearned profit of PLN 53.41 million (Tab. 5). However, much higher external costs will occur due to the occurrence of a depression funnel. In the first variant, covering only the area of the joint depression funnel for the Jóźwin IIB open pit and the designed Ościsłowo open-pit, annual loss in production was estimated at PLN 29.8 million (PLN 15.8 million in crop production and PLN 13.9 million per year in animal production) and external costs at the level of PLN 19.3 million. Within 15 years, that is, in the period related to the delay in the reconstruction of water relations in this depression funnel as a result of the Ościsłowo open pit, no agricultural products worth PLN 446.3 million will be produced, which will translate into external costs at the level of nearly PLN 289.9 million. However, each year of delay in starting the drainage of the Ościsłowo open pit outside of 2018 will generate additional external costs at the level of approximately PLN 19.3 million. The Ościsłowo open-pit will also create its own depression funnel, which will cover new areas not affected by the depression of the Jóźwin IIB opencast and the area affected by the depression funnel for tertiary waters, where the formation of the Ościsłowo open pit will result in a quaternary aquifer. The maximum annual losses in agricultural production in this area will amount to PLN 13.5 million per year, and in the entire period of impact of the outcrop will be about PLN 517.5 million, while external costs will amount to PLN 9.1 million and PLN 348.7 million, respectively. In total, external costs for agriculture caused by the launch of the Ościsłowo open-pit may amount to PLN 0.69 billion. If, on the other hand, the effects of drainage in the full estimated area are taken into account (option II), external costs may amount to as much as PLN 80.5 million annually (the value of non-produced agricultural production is PLN 116.5 million per year). However, since the majority of this area coincides with the impact area of the Jóźwin IIB open-pit, costs within 15 years will amount to about PLN 1.26 billion.

In the case of the Dęby Szlacheckie open-pit, annual losses in agricultural production in the open-pit area will amount to PLN 6.1 million annually, of which PLN 2.9 million will be generated from crop production and PLN 3.2 million from animal production, which translates to around PLN 1.5 million of lost profits. Losses in agriculture in the area of expected depression funnels will amount to PLN 59.9 million annually, of which PLN 33.9 million will be generated in crop production and PLN 26.0 million in animal production. Within 45 years of impact of the open pit on agriculture, it will result in losses in agricultural production in Option I at the level of PLN 2.97 billion, which gives PLN 1.82 billion of external costs. However, as in the case of the Ościsłowo deposit, the scope of the outgrowth impact exceeds the designated area of depression funnels; therefore, the external costs in option II will be higher and will amount to a maximum of PLN 92.1 million annually, and within 45 years approximately PLN 3.65 billion. Annual losses in agricultural production will amount to PLN 140.7 million annually and PLN 5.55 billion in the entire analysed period.

The deposits of Oczkowice, the largest and most abundant coal in the analysed deposits, are also located in the area with the most intensive agriculture in Poland (especially in the field of animal production). External costs in the area of the planned outcrop will amount to PLN 12.0 million annually, of which two thirds will be generated in animal production – PLN 7.9 million, while the remaining PLN 4.1 million in plant production.

Tab. 5. Annual costs in plant and animal production

Specification		Ościsłowo				Dęby Szlacheckie			Oczkowice		
		Outcrop	Variant I		Variant II	Outcrop	Variant I	Variant II	Outcrop	Variant I	Variant II
			common hopper	own hopper							
Plant production											
Area (ha UR)		1177	29979	11674	118095	1497	47141	131051	5898	22500	260000
loss (%)		60.0	17.7%*, 25.0%**	17.7%*, 25.0%**, 7.3%***	17.7	60.0	22.1	17.7	60.0	25.0	17.7
acreage (ha)	cereals	681	17341	6753	63935	789	25965	70319	3151	12022	138921
	potatoes	18	450	175	1743	35	867	2427	116	444	5135
	sugar beets	14	347	135	3379	29	1087	3393	142	541	6249
	rape	44	1115	434	11147	94	3559	11142	369	1409	16277
	others	421	10726	4177	37891	549	15663	43770	2119	8084	93417
Losses (PLN m / year)	cereals	0.93	7.84	3.32	29.23	1.17	14.75	32.57	6.76	10.75	77.81
	potatoes	0.13	1.10	0.47	4.43	0.29	2.75	6.28	1.41	2.23	16.18
	sugar beets	0.05	0.42	0.18	4.55	0.13	1.82	4.59	0.88	1.40	10.13
	rape	0.10	0.81	0.34	8.62	0.24	3.43	8.68	1.35	2.14	15.50
	others	0.67	5.67	3.32	21.66	1.06	11.12	25.84	5.83	9.27	67.08
	Razem	1.87	15.85	7.64	68.49	2.89	33.87	77.97	16.23	25.80	186.70
External costs (PLN m * $year^{-1}$)		0.47	15.85	7.64	68.49	2.89	33.87	77.97	16.23	25.80	186.70
Animal production											
Area powiatów (% UR)[1]		1.28	32.52	12.66	39.44	2.09	15.68	25.55	5.62	21.43	75.28
Loss (%)	cattle	60.0	15.0*, 20.0**	15.0*, 20.0**, 5.0%***	15.0	60.0	17.7	15.0	60.0	20.0	15.0
	cows	60.0	15.0*, 20.0**	15.0*, 20.0**, 5.0%***	15.0	60.0	17.7	15.0	60.0	20.0	15.0
	swine	60.0	9.0*, 12.5**	9.0*, 12.5**, 3.5***	9.0	60.0	11.1	9.0	60.0	12.5	9.0
	sows	60.0	9.0*, 12.5**	9.0*, 12.5**, 3.5***	9.0	60.0	11.1	9.0	60.0	12.5	9.0
Amount in poviats (pcs)	cattle	48144	48144	48144	134437	45132	165771	214093	100244	100244	273982
	cows	18492	18492	18492	50082	21237	65876	82930	37494	37494	96517
	swine	95921	95921	95921	334314	48167	297435	488626	479136	479136	1245727
	sows	9410	9410	9410	33221	5547	31498	50217	43746	43746	119290
Losses (PLN m / year)	beef livestock	0.42	2,97	1.24	10.43	0.56	5.47	11.93	3.94	5.01	37.32
	milk	1.03	7.26	3.03	23.54	1.95	14.91	31.33	9.23	11.73	79.58
	fatteners	0.65	2.77	1.17	10.72	0.53	4.19	10.00	14.24	11.32	74.44
	piglets	0.21	0.91	0.38	3.31	0.20	1.47	3.33	4.33	3.44	23.76
	Total	2.32	13.91	5.82	47.99	3.24	26.03	56.59	31.74	31.50	215.10
External costs (PLN m * $year^{-1}$)		0.58	3.48	1.46	12	0.81	6.51	14.15	7.93	7.88	53.78
Annual losses agricultural production (PLN m)		4.19	29.76	13.46	116.49	6.13	59.90	134.55	47.97	57.30	401.81
Annual external costs agricultural production (PLN m)		1.05	19.32	9.09	80.49	1.53	40.38	92.11	11.99	33.67	240.48
Time to generate losses (years)		51	15	51[a], 15[b], 36[c]	15	45	45	15[d], 25[e], 45[f]	100	100	100
Losses caused by the outcrop (PLN m)		213.64	446.34	517.47	1747.34	275.97	2695.43	5275.37	4796.84	5729.94	40180.51
External costs caused by the outcrop (PLN m)		53.41	289.86	348.65	1207.40	68.99	1817	3584.92	1199.21	3367.26	24047.74
Total losses with the open pit area (PLN m)		x	691.92	1260.92	x	1885.99	3653.92	x	4566.47	25246.95	

Source: Own calculations

1 - the share of the surface of the outcrop or the funnel of depression in the total area of the poviats

* - the level of losses for the tertiary depression area

** - level of losses for the Quaternary depression area

*** - the level of losses for the area of the joint funnel of the depression, Ościsłowo and Jóźwin IIB.

Tab. 6. Annual costs in the sale of the agro-food industry

Specification	Ościsłowo				Dęby Szlacheckie			Oczkowice		
	Outcrop	Variant I		Variant II	Outcrop	Variant I	Variant II	Outcrop	Variant I	Variant II
		common hopper	own hopper							
area (ha)	1177	29979	11674	118095	1497	47141	131051	5898	22500	260000
loss (%)	60.0	17.7%*, 25.0%**	17.7%*, 25.0%**, 7.3%***	17.7	60.0	22.1	17.7	60.0	25.0	17.7
purchase (PLN * ha^{-1})	1642.8	1642.8	1642.8	1642.8	1642.8	1642.8[2], 1737.8[3]	1642.8[2], 1737.8[3]	1642.8	1642.8	1642.8
losses (PLN m)	2.32	19.64	8.32	71.10	2.95	35.09	78.56	11.63	18.48	151.20
losses (PLN m) – beef livestock	0.68	4.75	1.98	16.69	0.89	8.75	19.08	6.30	8.01	59.72
losses (PLN m) – milk	1.65	11.62	4.85	37.66	3.11	23.85	50.13	14.76	18.77	127.33
losses (PLN m) – fatteners	1.04	4.44	1.87	17.15	0.85	6.70	16.00	22.79	18.11	119.11
losses (PLN m) – total	3.37	20.80	8.71	71.50	4.86	39.30	85.22	43.85	44.89	306.16
losses agricultural production (PLN m)	5.69	40.45	17.03	142.60	7.81	74.39	163.77	55.48	63.38	457.36
Time to generate losses (years)	51	15	51[a], 15[b], 36[c]	15	45	45	15[d], 25[e], 45[f]	100	100	100
Losses caused by the outcrop (PLN m)	290.14	606.74	655.09	2139.00	351.43	3347.55	6433.81	5547.68	6337.55	45736.08
External costs caused by the outcrop (PLN m)	10.15	21.24	22.93	74.87	12.30	117.16	228.18	194.17	221.81	1600.76
Total external costs with the open pit area (PLN m)	x	**54.32**		**85.02**	**x**	**129.46**	**237.48**	**x**	**415.98**	**1794.93**

Source: Own calculations. Purchase prices based on Purchase and prices of agricultural products in 2011, 2012, 2013, 2014 and 2015. CSO

2 - in the Wielkopolskie Voivodeship

3 - in the Kujawsko-Pomorskie Voivodeship

Other as given in Tab. 5.

The large depth of the deposit and the estimated size of the depression hopper (option I) also translate into the expected external costs in agriculture, which were estimated at PLN 33.7 million per year, while in the more realistic option II, as much as PLN 240.5 million per year. After taking into account the external costs from the open-pit area, it will amount to PLN 45.7 million and PLN 252.5 million annually, which in 50 years of estimated production and 50 years of reconstruction of water relations means external costs at the level of PLN 3.37–24.04 billion. Losses in unrealized agricultural production will be significantly higher and will amount to PLN 10.5 billion over the entire period of impact in option I and PLN 45.0 billion in option II, of which about 55% will not be generated in animal production.

Because external costs mean the estimated loss of profits earned by farmers in agricultural production, therefore, in the case of the three analysed outposts, farmers will not allocate for investment and consumption (which will translate to a large extent the drop in turnover of local companies, not only from agriculture) from PLN 117.0 to 427.7 million a year.

Significant external costs will also be borne by the agro-food industry. The raw material restrictions for processors, who buy most or all of the agricultural raw materials from farmers from areas affected by the drainage of the outcrops, will be particularly severe. The estimated annual decrease in the turnover of agro-food industry enterprises related to the reduction of supply from the Ościsłowo open-pit areas will amount to PLN 5.7 million annually from the open pit area and PLN 57.5 million per year from the designated depression funnel (option I) to PLN 142.6 million for the impact area of the open pit in option II (Tab. 6). In the case of the Dęby Szlacheckie open-pit, it may amount to PLN 7.81 million, PLN 74.4 million and PLN 163.8 million, respectively. However, the highest production losses will affect processors supplying the area of impact of the Oczkowice open-pit, as they may lose sales of PLN 55.5 million, PLN 63.4 million and PLN 457.4 million, respectively. In the case of Ościsłowo and Dęba Szlachecka open-pits, the share of agri-food products of plant and animal origin was similar, while in the Oczkowice deposit, animal products account for about 70% of farm sales. The drop in turnover will also translate into a drop in profits, which with 3.5% turnover profitability will mean annual external costs for the deposits 2.2–5.2 million PLN annually, 2.8–6.0 million PLN annually and 4.2–17.9 million PLN per year, which will not be launched for investments and dividends (these costs will be borne mainly by enterprises located near the planned mines). During the whole period of impact of opencast mines, it will be 54.3–85.0 million PLN, 129.5–237.5 million PLN and 416.0–179.9 million PLN respectively.

Costs in wholesale and retail trade will be low, as shortages of food products will be imported, or exports from Poland will be reduced.

In total, in the case of the three outlets under analysis, the expected external costs that would fall on agriculture in the entire period of impact may amount to PLN 7.1 billion, if only the estimated depression areas are taken into account, to the most probable PLN 30.2 billion, if it is covered by the analysis, the entire estimated area of impact of open-cast mines. The reduction in the supply of agricultural raw materials will also translate into external costs of the agri-food industry, closely related to agriculture, for which they may amount to PLN 0.6 billion and PLN 2.1 billion, respectively, which gives the total external costs at the level of 7.7 to 32.3 billion PLN. The decline in agricultural production in agriculture and agri-food processing will be much higher and amount to PLN 31.8–113.0 billion. Coal resources in the three analysed deposits are estimated at 1.116 million tonnes. With the price of lignite at PLN 75–100 per tonne, the value of coal to be extracted is PLN 83.7–111.6 billion and may be lower than the value of production lost by agriculture and the agri-food industry.

6 Summary

Summing up, it can be stated that the opening of new lignite opencasts in Wielkopolska entails high economic costs due to the probable very high external costs incurred by agriculture and the agri-food industry, which should be included in the process of issuing decisions by relevant state administration authorities.

If other external costs and risks to the environment were taken into account, social and other costs that were not the subject of this analysis, there is a high probability that none of the analysed open-pits will contribute to the increase of national wealth. In the case of open-pits, that is, Ościsłowo, Dęby Szlachecki, the main reason is the small amount of brown coal in the deposit, which will be extracted for a relatively long time, which in turn translates into a long time of negative impact on the environment. In the case of the Oczkowice deposit, about 1 billion tons of brown coal with high external costs, the location in the area with the most intensive agriculture in Poland resulted from having the best soils in Wielkopolska and the largest concentration of livestock in Poland, especially pigs.

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