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# ENVIRONMENTAL COSTS FOR EXPLOITATION VARIANTS OF RACIBÓRZ DRY POLDER

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## KOSZTY ŚRODOWISKOWE WARIANTÓW EKSPLOATACJI POLDERU RACIBÓRZ

**STRESZCZENIE:** Celem badań była wycena kosztów środowiskowych związanych z różnymi wariantami eksploatacji polderu Racibórz Dolny na Odrze. Dla czterech wariantów odpływu wody z polderu (woda 2-letnia, 5-letnia, 10-letnia i 20-letnia) określono powierzchnię zagrożonych obszarów Natura 2000 i innych ekosystemów. Wycena metodą wskaźnikową wykazała znaczną przewagę wariantu III z najsłabszą ochroną przeciwpowodziową (zatrzymywanie wody 20-letniej lub większej). Wariant ten zagrozi tylko 2% powierzchni siedlisk Natura 2000 w dole rzeki i nie zaszkodzi lasom w czaszy polderu, generując 37 razy mniejsze koszty środowiskowe niż wariant I.

**SŁOWA KLUCZOWE:** świadczenia ekosystemów, koszty środowiskowe, wycena środowiska, polder Racibórz, Natura 2000

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## Introduction

Natural river valleys are valuable habitats and supply ecological services. Construction of dam and outflow control can significantly change hydrographic conditions downstream. Modern investments in water management should balance flood control of population and protection of wetlands. Dry polders are areas for temporal water retention in case of bigger river flows. They are alternative for construction of conventional water reservoirs with permanent pool.

Racibórz dry polder is one of rare large investments in contemporary water management in Poland. Serious plans of construction were undertaken after catastrophic flood on Oder river in 1997. Feasibility study<sup>1</sup> from 2003 proposed destined construction of water reservoir. In 2005 first environmental impact assessment (EIA) report<sup>2</sup> was prepared for investment. This report was rejected next year by Polish Ministry of Environment, because report not showed impact of investment on Natura 2000 areas in Oder valley downstream dam. Such assessment was included in EIA for „Project of flood control for Oder valley”<sup>3</sup> which covered also construction of Racibórz dam.

New EIA report<sup>4</sup> prepared in 2009 assumed construction of dry polder instead of water reservoir. This report was completed in 2011 and environmental approval was valid in next year. Construction of dry polder started in 2013 and is planned to finish in 2017.

## Exploitation variants of Racibórz dry polder

Decrease of frequency of wetlands flooding downstream dam could be main danger for nature associated with exploitation of water reservoir in Racibórz. According to results of simulations for flood wave with probability of occurrence once a 10 years, water level in Oder could drop by 1.0-2.5 m on distance 150 km down Racibórz.

Regular flooding is important for conservation and longevity of different terrestrial and water ecosystems. Especially habitats located above river are exposed to flow limitation. Willow-poplar riparian forests are substituted by

<sup>1</sup> *Studium wykonalności zbiornika Racibórz Dolny na rzece Odrze. Raport główny*, Warszawa 2003.

<sup>2</sup> *Zbiornik przeciwpowodziowy Racibórz Dolny. Raport o oddziaływaniu inwestycji na środowisko*, Warszawa 2005.

<sup>3</sup> *Projekt ochrony przeciwpowodziowej doliny Odry. Ocena oddziaływania na środowisko. Streszczenie*, Warszawa-Gliwice-Wrocław 2005.

<sup>4</sup> *Raport o oddziaływaniu na środowisko przedsięwzięcia polegającego na budowie zbiornika przeciwpowodziowego Racibórz Dolny na rzece Odrze woj. śląskie – polder*, Warszawa 2009.

oak-hornbeam forests (dry-ground forests) which are accommodated to flooding lack. Rare alder-ash riparian forests can totally disappear<sup>5</sup>.

In second EIA report three variants for exploitation of Racibórz dry polder were proposed<sup>6</sup>:

- variant I, proposed by investor, with assumption of outflow from dry polder equal to 2-year flood (running of reservoir for flows higher 470 m<sup>3</sup>/s); in result areas presently flooded once a 5 year or less frequently would be devoid of flooding with disappearance of habitats (96% of Natura 2000 areas);
- variant II, called „rational alternative variant”, with assumption of outflow from dry polder equal to 5-year flood (780 m<sup>3</sup>/s); in result areas presently flooded once a 10 year or less frequently would be devoid of flooding with losses of 43% of Natura 2000 areas;
- variant III, called „the most beneficial for nature”, with weaker flood control (showed risk of ground water-logging for 35 localities) and assumption of outflow from dry polder equal to 20-year flood (1210 m<sup>3</sup>/s); in result areas presently flooded once a 20 year or more frequently would be preserved and only 2% of Natura 2000 areas would be losses.

Other variant analysed by the Ministry of Environment<sup>7</sup> – outflow from dry polder equal to 10-year flood (1070 m<sup>3</sup>/s) with losses of 27% of Natura 2000 areas was not considered in this EIA report. Variants of outflow of 50-year flood (1800 m<sup>3</sup>/s) or 100-year flood (2300 m<sup>3</sup>/s) were also not considered, although initial reservoir conception assumed interception only catastrophic waters. It is important that Oder flood embankments were constructed for 100-year flood. These variants could eliminate problem of dry polder impact on priority habitats – willow-poplar riparian forests.

In dry polder bowl negative impact of exploitation was expected in result of destruction of riparian forests in situation of often and long flooding with height 2-3 m above ground level. For each variant oxbow lake on Plinc (Pięsnica) stream with area 220 ha will be destructed by construction of dam<sup>8</sup>.

Variant III with reduction of flow to 1210 m<sup>3</sup>/s (flood with probability of occurrence once a 20 years) was finally chosen for implementation. This variant joins considerably less intervention in Oder water regime (leaving of approximate to natural flows in river bed) with flood control. Variant III also allows to preserve Natura 2000 habitats in dry polder bowl. Time for maximum water damming (3-4 days) is too short for negative impact on habitats of forest „Las koło Tworkowa”. Additionally obligation for environmental compensation<sup>9</sup> was determined in decision of the General Directorate for Environmental Protection (GDOŚ).

<sup>5</sup> *Projekt ochrony...*, op. cit., p. 25.

<sup>6</sup> *Raport o oddziaływaniu...*, op. cit., p. 173.

<sup>7</sup> *Projekt ochrony...*, op. cit., p. 25.

<sup>8</sup> D. Panasiuk, R. Miłaszewski, *Koszty środowiskowe realizacji obiektów hydrotechnicznych na przykładzie zbiornika Racibórz*, in: *Studium środowiskowych i społecznych kosztów rozbudowy infrastruktury technicznej w województwie śląskim oraz sposoby ich minimalizacji*, Katowice 2010.

<sup>9</sup> *Analiza wpływu przedsięwzięcia „Budowa zbiornika przeciwpowodziowego Racibórz Dolny na rzece Odrze, woj. śląskie (polder)” na stan wód oraz zgodności projektu z art. 4(7) RDW*, copied material.

## Impact on habitats for different dry polder exploitation variants

Following Natura 2000 special areas of conservation (SACs) are located in Oder valley below dam and in scope of dry polder impact:

- “Łęg Zdzeszowicki” (site code PLH160011) with surface 619.9 ha – elm-ash riparian forests, oxbow lakes and dry-ground forests;
- “Żywocickie Łęgi” (PLH160019) with surface 101.7 ha – willow-poplar riparian forests;
- “Ujście Nysy i Stobrawy” (on “Shadow List 2010”) with surface 4961.6 ha – elm-ash and willow-poplar riparian forests, alluvial meadows and others, oxbow lakes and dry-ground forests;
- “Grądy w Dolinie Odry” (PLH020017) with surface 8348.9 ha – dry-ground forests, elm-ash and willow-poplar riparian forests, alluvial meadows and others, oxbow lakes.

In valley downstream there are also special protection area (SPA) “Grądy Odrzańskie” (PLB020002) with surface 19999.3 ha, nature reserves, landscape parks, nature and landscape complexes, ecological sites and natural monuments<sup>10</sup>. There are following protected areas in dry polder bowl and its surroundings:

- SAC “Las koło Tworkowa” (PLH240040) with surface 115.1 ha (projected nature reserve) – elm-ash and willow-poplar riparian forests;
- SPA “Stawy Wielikąt i Ligota Tworkowska” (PLB240003) with surface 914.5 ha, covered ponds Wielikąt (nature and landscape complex) and forest Las Tworkowski;
- natural valuable: oxbow lake on Oder in Sudół surroundings, oxbow lake on Plinc stream with ponds close Brzezcie and exploitation hollow close Nieboczowy<sup>11</sup>.

Surface of ecosystems which could disappear for respective exploitation variants of Racibórz dry polder are showed in table 1. From among 38 thous. ha of areas in Oder valley downstream dam and flooded once a 50 year or often, calculation covered 4968 ha of the most natural valuable ecosystems sensitive to flooding absence (Natura 2000 habitats) and 8 thous. ha of remaining green crops. Additionally 522 ha of forests and meadows in dry polder bowl were considered. They will stop to serve production function but will be flooding areas.

Impact of dry polder exploitation variants on water ecosystems and arable grounds in dry polder bowl was not considered.

<sup>10</sup> Natura 2000, [www.natura2000.gdos.gov.pl](http://www.natura2000.gdos.gov.pl) [23-09-2014].

<sup>11</sup> *Raport o oddziaływaniu...*, op. cit., p. 497.

Table 1  
Surface of lost ecosystems for exploitation variants of Racibórz dry polder

Ecosystems	Reduction of surface for exploitation variants [ha]			
	variant I (reduction to 2-year flood)	variant II (reduction to 5-year flood)	reduction to 10-year flood	variant III (reduction to 20-year flood)
Natura 2000 habitats downstream dry polder				
3150 (oxbow lakes, Natura 2000)	281.20	137.81	49.61	0.17
6440 (alluvial meadows, Natura 2000)	200.24	41.48	20.59	0.00
6510 (other meadows, Natura 2000)	1 410.17	693.29	311.59	59.20
*91E0 (willow-poplar riparian forests, Natura 2000)	425.50	136.04	91.04	8.13
91F0 (elm-ash riparian forests, Natura 2000)	2 440.40	1 118.30	879.59	47.52
2330 (dunes, Natura 2000)	2.07	0.00	0.00	0.00
Total Natura 2000 habitats sensitive to flooding absence	4 759.58	2 126.92	1 352.42	115.02
Remaining ecosystems downstream dry polder				
remaining green crops	6 460.31	5 298.23	3 435.39	1 335.19
Habitats in dry polder bowl				
forests and coppices	161.51	161.51	161.51	0.00
meadows and pastures	360.04	360.04	360.04	0.00
TOTAL	11 926.00	8 131.26	5 493.92	1 450.21

Source: D. Panasiuk, R. Miłaszewski, *Koszty środowiskowe...*, op. cit.

## Index method of environmental cost valuation

For valuation of environmental costs, index method based on Costanza et al.<sup>12</sup> results in 1994 dollars was used. These numbers are global averages and in future using of local valuations could be more appropriate. However these valuations are not available presently.

Average value of ecological services provided by ecosystems of lakes and rivers were valued by Costanza's team on 8 498 USD/ha annually, ecosystems of wetlands – 14 785 USD/ha annually (swamps/floodplains – 19 580 USD/ha), ecosystems of temperate forests – 302 USD/ha annually, ecosystems of grass/rangelands – 232 USD/ha annually, and other green crops – only 92 USD/ha annually<sup>13</sup>.

<sup>12</sup> R. Costanza et al., *The value of the world's ecosystems services and natural capital*, "Nature" 1997 no. 387, p. 253-260.

<sup>13</sup> D. Panasiuk, *Wartość środowiska w analizach kosztów i korzyści zbiorników wodnych w Polsce*, „Ekonomia i Środowisko” 2010 no. 1(37), p. 167-175.

These services are mainly non-market. Swamps and floodplains are ecosystems, which were valued, by Costanza's team, 2 times higher than services of water ecosystem with the same surface. Ecosystem services provided by floodplains composes of:

- water supply (provisioning of water by watersheds, natural reservoirs and aquifers and next draining in drought period) – 39%;
- limited flood control (part of disturbance regulation) as retention of lower flood waters in natural polder – 37%;
- recreational and cultural values – 11%;
- waste treatment (recovery of mobile nutrients) – 8%;
- other services as gas regulation – 4%.

Services provided by grass/rangelands composes of food production, nutrient control and erosion control. In result of flooding limitation these services could be lost or substituted by services provided by artificial reservoir (flood control and water retention). Services provided by temperate forests are raw material and food production (wood and ground cover), climate regulation, nutrient control and recreation<sup>14</sup>.

Global rough numbers can seem too simple, but they are not complicated and more communicable for practitioners as water management experts or other engineers. Żylicz<sup>15</sup> pays attention to simplification and lacks in estimations made by Costanza's team. However he ascertained they are useful reference and probably order of magnitude between ecosystem services of wetlands and forests is preserved<sup>16</sup>.

Costanza's team estimation was used for example in WWF Polska elaboration<sup>17</sup> concerning valuation of areas flooded by damming of Włocławek reservoir in 1970. Indexes of ecosystem services were multiplied by surfaces of different habitats with rate 4 PLN/USD and next capitalised using three different discount rates<sup>18</sup>.

## Environmental costs for different dry polder exploitation variants

For estimation of environmental costs associated with exploitation of Racibórz dry polder, values of ecosystem services converted to Polish złoty with purchasing power parity rate 2 PLN/USD, were used.

<sup>14</sup> D. Panasiuk, *Wycena świadczeń ekosystemów zbiornika Goczałkowice wraz z otoczeniem*, Katowice 2012.

<sup>15</sup> T. Żylicz, *Wycena usług ekosystemów. Przegląd wyników badań światowych*, „Ekonomia i Środowisko” 2010 no. 1(37), p. 31-45.

<sup>16</sup> T. Żylicz, *Valuating ecosystem services*, „Ekonomia i Środowisko” 2012 no. 2(42), p. 18-38.

<sup>17</sup> *Studium kompleksowego rozwiązania problemów stopnia i zbiornika Włocławek. Prognoza skutków społeczno-ekonomicznych i środowiskowych*, Warszawa 2001.

<sup>18</sup> D. Panasiuk, op. cit., p. 172.

Table 2  
Environmental costs connected with exploitation variants of Racibórz dry polder

Ecosystems	Losses of ecological services [million PLN annually]			
	variant I (reduction to 2-year flood)	variant II (reduction to 5-year flood)	reduction to 10-year flood	variant III (reduction to 20-year flood)
Natura 2000 habitats downstream dry polder				
3150 (oxbow lakes, Natura 2000)	11.01	5.40	1.94	0.01
6440 (alluvial meadows, Natura 2000)	7.84	1.62	0.81	0.00
6510 (other meadows, Natura 2000)	55.22	27.15	12.20	2.32
*91E0 (willow-poplar riparian forests, Natura 2000)	16.66	5.33	3.57	0.32
91F0 (elm-ash riparian forests, Natura 2000)	95.57	43.79	34.44	1.86
2330 (dunes, Natura 2000)	0.08	0.00	0.00	0.00
Total Natura 2000 habitats sensitive to flooding absence	186.39	83.29	52.96	4.50
Remaining ecosystems downstream dry polder				
remaining green crops	3.00	2.46	1.59	0.62
Habitats in dry polder bowl				
forests and coppices	0.10	0.10	0.10	0.00
meadows and pastures	0.17	0.17	0.17	0.00
TOTAL	189.65	86.01	54.82	5.12

Source: D. Panasiuk, R. Miłaszewski, *Koszty środowiskowe...*, op. cit.; D. Panasiuk, *Wartość środowiska...*, op. cit., p. 174.

For Natura 2000 habitats located in scope of dry polder impact and sensitive to flooding absence, ecosystem services index 39 160 PLN/ha annually for floodplains was used. For remaining green crops in Oder valley located downstream dam and for meadows and pastures in dry polder bowl index 464 PLN/ha was taken. For forests and coppices in dry polder bowl it was index 604 PLN/ha. Table 2 shows environmental costs calculated for these assumptions.

Environmental costs were estimated on level 190 million PLN annually for variant I of dry polder exploitation, 86 million PLN/year for variant II, 55 million PLN/year for capturing of 10-year flood and only 5 million PLN/year for variant III. These costs for variant I would be 37 times more than for finally chosen variant III. For floods other than catastrophic ones, natural floodplains deliver high level of flood control services.

After cost capitalisation for 30-years period, environmental costs for variant I are equal to 3.3 billion PLN (with discount rate 4%) and 2.1 billion PLN (with discount rate 8%). For variant II these costs were estimated on level 1.0-1.5 billion PLN, for capturing of 10-year flood – 0.6-1.0 billion PLN, and for variant III – only 58-89 million PLN, see Table 3.

Table 3  
Annual and capitalised environmental costs connected with exploitation variants of Racibórz dry polder

Environmental costs	Losses of ecological services (million PLN annually)			
	variant I (reduction to 2-year flood)	variant II (reduction to 5-year flood)	reduction to 10-year flood	variant III (reduction to 20-year flood)
Annual costs	190	86	55	5
30-year capitalisation, $r = 4\%$	3 279	1 487	948	89
30-year capitalisation, $r = 8\%$	2 135	968	617	58

Source: D. Panasiuk, R. Miłaszewski, *Koszty środowiskowe . . .*, op. cit.

Of course capitalised environmental costs for discount rate 8% are lower than these costs calculated for discount rate 4%.

## Conclusions

Comparative analysis of losses in ecosystems show that lower level of environmental costs will be achieved for finally chosen variant III of dry polder exploitation (running of reservoir for flows higher than 20-year flood). However only variants of reservoir running for bigger flows could allow totally preserve priority habitats.

Analysis of available elaborations allowed to estimate surfaces of natural valuable floodplains and meadows, which could be exposed to ground overdrying in result of implementation of respective exploitation dry polder variants. Calculated environmental costs cover only use value of ecosystem but not consider their option and existence values. Currency rate and inflation are sources of next uncertainties. Using of local Polish estimations could decrease level of environmental costs but consideration of significance of ecological corridors could increase these costs. These reasons limit use of absolute numbers for environmental costs.

*Estimation of environmental costs for exploitation variants of Racibórz dry polder was made in framework of works on elaboration „Study on environmental and social costs of development of technical infrastructure in Silesia province and measures of their minimisation”. Author thanks to Centre for Natural Heritage of Upper Silesia (CDPGŚ) in Katowice for works financing.*