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Artificial water reservoirs as nature conservation areas in Poland

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Abstract: Dams give rise to man-made water reservoirs. The most important positive effects are: flood protection, electricity generation, irrigation of agricultural land, and water storage for consumption. However, numerous authors emphasise the negative environmental impacts associated with these structures. These impacts include the interruption of the ecological corridor, alterations in the abiotic and biotic components of river valley ecosystems, and erosion of banks and riverbeds downstream of the dam. Nevertheless, it is asserted that the construction of dams has also created areas of natural value around many artificial water reservoirs in Poland. This article presents compiled data on nature-protected areas that have been originated from the establishment of 58 artificial water reservoirs formed as a result of the construction of a large dam in Poland. Out of the examined water reservoirs, 79.3% were linked to some form of nature protection. Particularly, protected landscape areas were prevalent in the vicinity of artificial water reservoirs, and nature reserves were designated on six of them. Examples include reservoirs where the entire area (Mietków Dam, Turawa Dam, Jeziorsko Dam) or a significant part (Goczałkowice Dam) has been covered by Natura 2000 nature protection. Examples are also given of reservoirs where the immediate surroundings have been covered by nature protection, as the damming of water has created marshy areas conducive to the creation of breeding grounds. These findings affirm that dams contribute positively to the advancement of certain nature conservation zones.

Keywords: artificial water reservoir, dam, Natura 2000, nature protection, nature reserve

INTRODUCTION

Artificial water reservoirs play a crucial role in human development. They protect against floods, mitigate the effects of drought, ensure access to and storage of drinking water, enable the generation of electricity, and provide opportunities for recreation. Artificial reservoirs are also used as cooling water ponds (Mazierski and Kostecki, 2021). Despite their obvious advantages, they also have a negative impact on the environment, as do other technological facilities (for comprehensive discussion on mutual influence of humans, technology, and the environment, see Pietrucha-Urbanik and Rak (2023)). An undated report by International Rivers (no date) argues that dams disturb river ecological corridors, particularly by blocking fish migrations. Many authors claim that river impoundment by a dam not only prevents fish migration but also causes significant species changes (Penczak, Głowacki and Galicka, 1998; Głowacki *et al.*, 2011). Czerniawski *et al.* (2010) argue that even a 0.5 m impoundment significantly disrupts a stream's ichthyofauna. Man-made reservoirs create artificial aquatic habitats that undergo eutrophication and are inhabited by specific fish communities (Wołos and Wiśniewolski, 2009). The creation of such reservoirs can also drive spatial and temporal shifts in the diet of aquatic predators, such as the Eurasian otter *Lutra lutra* (Brzeziński, Chibowska and Romanowski, 2013). Dams alter water temperature and chemical composition, retain nutrient-rich sediments, and increase riverbed erosion downstream; these processes can lead to plant desiccation and water shortages in wells, according to an undated

report by International Rivers. Dams may contribute to large-scale negative impacts: for example Milliman (1997) expressed concerns that the artificial reservoir at the Iron Gate on the Danube, by trapping silicon in sediments, could potentially disrupt the Black Sea ecosystem and ultimately lead to a major ecological catastrophe. The retention of sediments is also considered a negative impact of artificial reservoirs (e.g. Sedláček *et al.*, 2022).

Based on examples from Poland, this article demonstrates that dams and artificial reservoirs can positively influence nature conservation. Official state conservation designation is the most compelling evidence of an area's ecological significance.

MATERIALS AND METHODS

HYDRAULIC STRUCTURES

The study examines artificial water reservoirs formed by large dams in Poland. According to the International Commission on Large Dams (no date), a large dam is at least 15 m high from the lowest foundation to the crest, or 5–15 m high and impounds more than 3 mln m^3. The examination involved the Central Register of Forms of Nature Conservation in Poland (Pol.: Centralny Rejestr Form Ochrony Przyrody) (GDOŚ, no date) to determine whether these structures are associated with forms of nature conservation (FoNC) listed below. The comparison excluded the area adjacent to the Pieniny National Park and the Niedzica Reservoir since the National Park was established in 1932, whereas the dam and reservoir were created in 1997. Therefore, there is no basis to conclude that the artificial reservoir is the origin of nature conservation areas in this case. The study also excluded the Wisła Czarne dam, where a reserve was established in 1959. Although the reserve was created that year, design work for the artificial reservoir also began in 1959. Construction of the dam started in 1968 and was completed in 1973. The available monograph (Olszamowski and Rożnowska, 1988) does not explain why the dam was built within a protected area. Today, the entire reservoir is designated as a natural reserve.

FORMS OF NATURE CONSERVATION IN POLAND

In Poland, FoNC defined in the Act of April 16, 2004, on Nature Conservation, chapter 2 (Ustawa, 2004; GDOŚ, no date) include the following:

1) national parks: designated areas distinguished by exceptional natural, scientific, social, cultural, and educational values, encompassing a minimum area of 1000 ha;
2) nature reserves: areas preserved in a natural or minimally altered state, encompassing ecosystems, habitats, and species of plants, animals, and fungi, as well as elements of the abiotic environment. They are characterised by exceptional natural, scientific, cultural, or landscape values;
3) areas of outstanding natural beauty: protected areas due to their natural, historical, cultural values, and landscape merits;
4) areas of protected landscape: designated areas protected for their distinctive landscapes, featuring diverse ecosystems and recognised for their importance in supporting tourism and recreation, as well as serving as ecological corridors;
5) Natura 2000 areas: designated to protect approximately 200 most valuable and endangered natural habitats, as well as over 1000 rare and endangered species;
6) nature monuments: include individual living and non-living features, or their clusters, distinguished by unique natural, scientific, cultural, historical, or landscape values;
7) documentation sites: scientifically and educationally significant locations featuring geological formations, fossil deposits, or mineral entities, which may not be visible or easily identifiable on the surface;
8) conservation areas: ecological remnants protected for their significant role in preserving biological diversity;
9) landscape nature protected complexes: include fragments of natural and cultural landscapes protected for their scenic or aesthetic values.

National parks and nature reserves are considered the most valuable regional FoNC.

RESULTS

GENERAL INFORMATION

The criteria for selecting dams, as outlined in the previous subsection, were met by 58 artificial water reservoirs. Of these, 46 reservoirs (79.3%) were associated with at least one FoNC. The remaining 12 reservoirs, which lacked any FoNC, were located in developed regions. All but one of them were recognised as popular recreational destinations for nearby urban populations. Additionally, three of these reservoirs continue to serve as water sources for industrial purposes.

In total, we documented 93 FoNC associated with artificial water reservoirs, accounting for only 0.22% of all FoNC registered in Poland (Tab. 1). The predominant FoNC near these artificial water reservoirs were areas of protected landscape, present at 58.6% of the analysed reservoirs. This was followed by areas of

Table 1. The number of different forms of nature conservation (FoNC) in Poland and near man-made reservoirs

No	Form of nature conservation	Number of FoNC	
		in Poland	near man-made reservoirs
1	national park	23	0
2	nature reserve	1,499	9
3	landscape park	124	13
4	area of protected landscape	407	34
5	Natura 2000 Bird Directive site	145	12
	Natura 2000 Habitat Directive site	848	13
6	natural monument	31,404	0
7	documentation site	178	1
8	conservation area	7,654	9
9	landscape-nature protected complex	331	2

Source: own study.

outstanding natural beauty and Natura 2000 Habitat Directive sites (each at 22.4%), and Natura 2000 Bird Directive sites (20.7%). Nine nature reserves (9.7%), including faunistic, phytosociological, and landscape reserves, were recorded at six artificial water reservoirs. Less common categories included documentation sites, found at 1.7%, and landscape nature protected complexes, identified at 3.7% of the reservoirs.

The time elapsed between completing construction and establishing a nature protection area for the reserve ranged from 10 to 53 years, with an average of 30.75 years and a median of 37 years. However, for a landscape park, this process took between 4 and 77 years, with an average of 42.7 years and a median of 47 years. Based on this data, it took on average about 35 years to create a protected area following the completion of dam and reservoir construction.

The presence of nature conservation forms around an artificial reservoir does not necessarily result from its construction. Both areas of outstanding natural beauty and areas of protected landscape cover regions much larger than the reservoir itself. When excluding these forms, along with landscape nature protected complexes and conservation areas, nature protection forms are found at 42 reservoirs, accounting for 72% of those studies.

Multiple forms of nature conservation (up to five FoNC) can be associated with a single artificial water reservoir. As many as 33% of reservoirs analysed had one FoNC, while 5% of the reservoirs had five forms of nature conservation (Fig. 1).

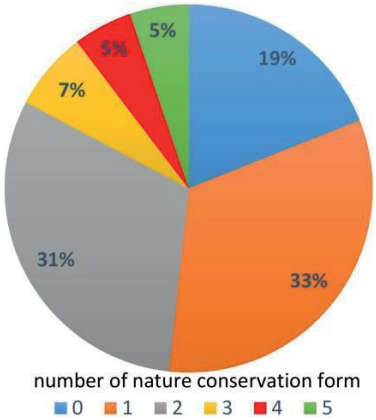

Fig. 1. The percentage of man-made reservoirs with different number of recorded forms of nature conservation (FoNC) in Poland; source: own study

CASE STUDIES

This section presents seven cases of protected areas that emerged solely due to the construction of a dam and water reservoir. Although the primary purpose of these structures were flood protection, water supply, or electricity generation, they can now have positive impact on the natural environment. The existence of these protected natural areas would not have occurred without the creation of the dam and its associated artificial reservoir.

The Mietków dam

The dam and reservoir were commissioned in 1986. This earth dam is 17 m high and 3.2 km long, with a capacity of 65 mln m^3 and a reservoir surface area of 9.29 km^2. The entire reservoir area was designated as Natura 2000 site 'Zbiornik Mietkowski' in 2007 (Fig. 2). According to the standard data form 'Zbiornik Mietkowski' (GDOŚ, no date k), it is inhabited by 24 bird species listed in Annexes I and II of the Birds Directive (Directive, 2009) (Tab. S1). During the breeding season, the area is an important refuge for three species listed in Annex I of the Birds Directive: Mediterranean gull (*Larus melanocephalus*), little tern (*Sterna albifrons*), and common tern (*S. hirundo*). The protected area is slightly larger than the reservoir, covering 11.94 km^2. The entire facility is located within the Scenic Park of the Bystrzyca Valley.

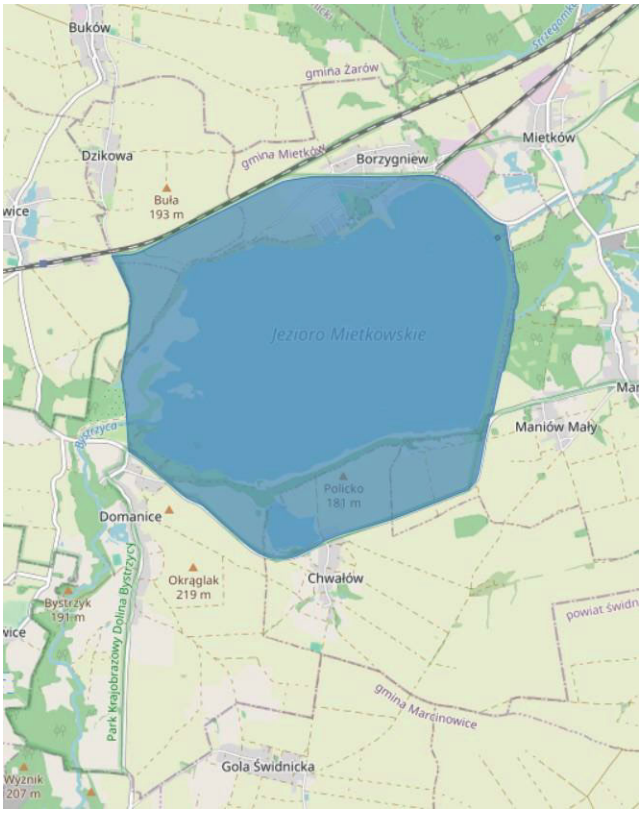

Fig. 2. The man-made 'Zbiornik Mietkowski'; the blue colour marks Natura 2000 site; source: own elaboration based on https://geoserwis.gdos.gov.pl/mapy

The Turawa dam

The Turawa dam is a 13-meter-high earth dam with a reservoir capacity of 108 mln m^3. It stretches 8 km in length with a maximum width of nearly 4 km and depth of 5 m. The reservoirs covers an area of 2,080 ha. The construction of the Turawa dam and reservoir took place between 1933 and 1939 along the Mała Panew River (Fig. 3). Initially, the reservoir was built to regulate the flow of the Oder River and provide cooling water for the Opole Power Plant, located approximately 14.5 km to the west. Additionally, the reservoir was designed to offer recreational and relaxation opportunities. The entire Turawa Reservoir is part of the Natura 2000 Bird Directive area, established on 14 November 2008. This protected area, covering 2,123.81 ha, encompasses the entire reservoir and its surrounding coastal areas. The total of 70 species of birds listed in Annexes I and II of the Birds Directive (Directive, 2009) (Tab. S1) have been recorded in the standard data form 'Zbiornik Turawa'

Fig. 3. The man-made 'Zbiornik Turawa'; the blue colour marks the Natura 2000 site; source: own elaboration based on: https://geoserwis.gdos.gov.pl/mapy

(GDOŚ, no date l) in the area, including breeding populations of black-necked grebe (*Podiceps nigricollis*), whiskered tern (*Chlidonias hybridus*), and black tern (*C. niger*).

The Dychów power plant

The earth dam Dychów is 27 m high and 408 m long. The dam creates a reservoir with a capacity of 4 mln m^3 and surface area 1 km^2. It was constructed between 1934 and 1936. In order to achieve higher damming for the hydroelectric power station located at the Dychów dam, a weir was built in Krzywaniec, about 20 km away. The entire Bóbr River was diverted into a lateral channel of 20.4 km, leading to a water reservoir located near the dam (Fig. 4). The oxbow lake of the Bóbr River is only fed by local sources. Due to carrying only a small amount of water, the oxbow lake became unattractive to humans. Years of negligible human interaction with the river have resulted in the oxbow lake becoming an excellent habitat for rare and protected species listed in Annexes II and IV of the Habitat Directive (Council Directive, 1992), including three invertebrate species, six fish species, two amphibians, fire-bellied toad (*Bombiba bombina*), and great crested newt (*Triturus creststus*), and two mammal species: Eurasian otter (*Lutra lutra*), and Eurasian beaver (*Castor fiber*) (Tab. S2). This area, designated as Natura 2000 site 'Dolina Dolnego Bobru', was established in 2011 (GDOŚ, no date f).

The Jeziorsko dam

The earth dam, standing 20 m high, forms a reservoir covering 42.4 km^2 with a capacity of 202.8 mln m^3. It was commissioned in 1986 and serves multiple purposes, including river flow regulation, irrigation of agricultural land, and recreation. Jeziorsko is the largest artificial water reservoir in the lowland region of central Poland (Fig. 5). The Jeziorsko reservoir is associated with several FoNC. These include the 'Jeziorsko' strict nature reserve of 1.97 km^2, established in 1998 (GDOŚ, no date m). The reserve and a Natura 2000 site 'Zbiornik Jeziorsko', established in 2008 (GDOŚ, no date j), for scientific, educational, and landscape purposes, protect habitats crucial for waterfowl conservation, hosting 58 bird species listed in Annexes I and II of the Bird Directive (Directive, 2009) (Tab. S1). During the breeding season, it is a refuge for 4 species listed in Annex I of the Birds Directive: great egret (*Egretta alba*), common tern (*Sterna hirundo*), whiskered tern (*Chlidonias hybrid*), and black tern (*Ch. niger*). Additionally, there are two Areas of Protected Landscape:

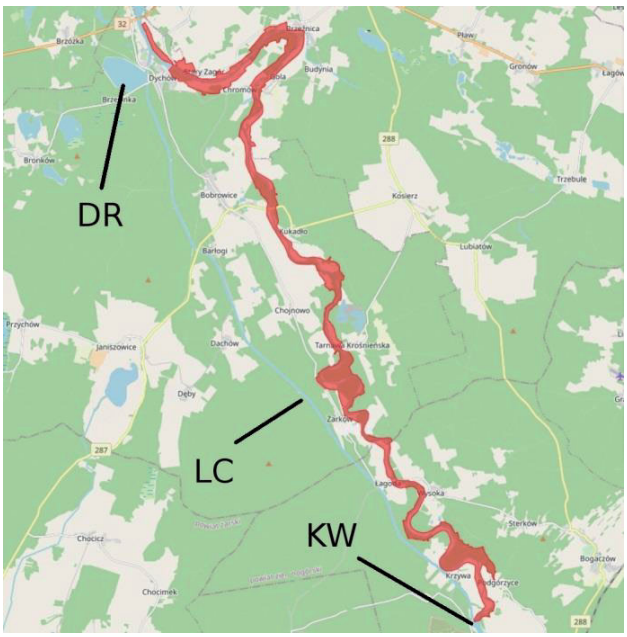

Fig. 4. The area protected by the construction of the 'Dychów' power plant: KW = Krzywaniec weir, LC = lateral canal, DR = Dychów reservoir; the protected area Lower Bóbr Valley encompassing the oxbow of the Bóbr River is highlighted in red; source: own elaboration based on: https://geoserwis.gdos.gov.pl/mapy

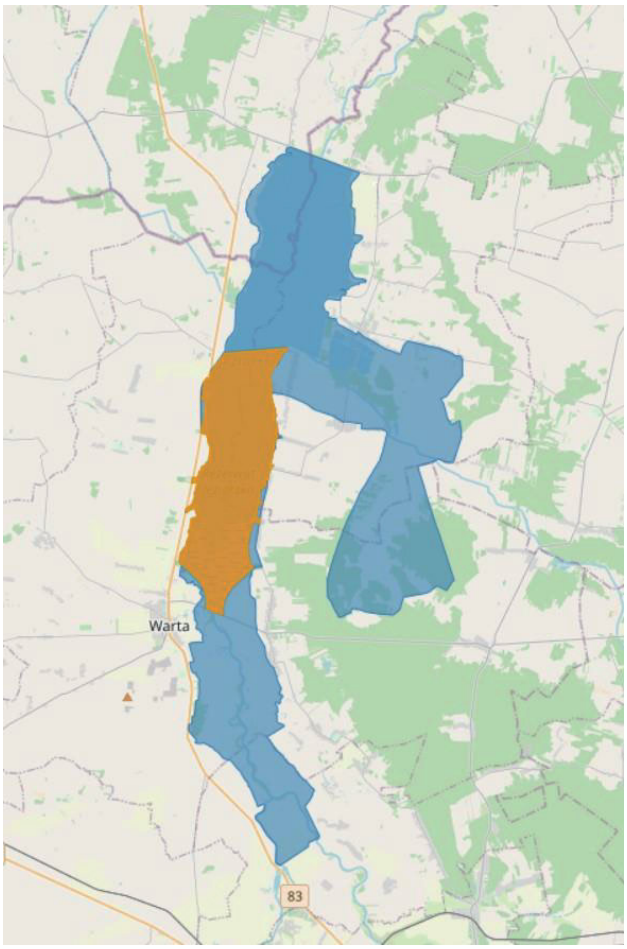

Fig. 5. The man-made 'Jeziorsko' reservoir; the blue colour marks the Natura 2000 site, the orange colour marks the strict nature reserve; source: own elaboration based on https://geoserwis.gdos.gov.pl/mapy

'Uniejowski' established in 1986 (GDOŚ, no date d) and 'Nadwarciański Park Krajobrazowy' estabilished in 1995 (GDOŚ, no date c), and a documentation site 'Siedlątków' (GDOŚ, no date r) established in 1994 near the Jeziorsko dam.

The Goczałkowice dam

The earth dam, standing 14 m high, creates a reservoir of 32 km^2 with a capacity of 168 mln m^3. Constructed in 1956, it supplies water to the Upper Silesian Industrial District. In 2019, a Natura 2000 habitat protection area 'Zbiornik Goczałkowicki – Ujście Wisły i Bajerki' (GDOŚ, no date i) was established covering the entire reservoir and small fragments along its shores (Fig. 6). The area protects several species listed in Annexes II and IV of the Habitat Directive (Council Directive, 1992), including one amphibian species, one fish species, and two mammal species: the otter and the beaver (Tab. S2). Additionally, the reservoirs lies within Natura 2000 bird area 'Dolina Górnej Wisły', established in 2004 (GDOŚ, no date g), which protects 52 bird species listed in Annexes I and II of the Bird Directive (Directive, 2009) (Tab. S1). The influence of the Goczałkowice reservoir has fostered wetlands in its vicinity, under protection since 1967. The strict 'Rotuz' nature reserve, covering 0.4 km^2, was established to preserve peat bogs for scientific, educational, and landscape purposes, including peat bogs within the forest and fragments of swampy and moist forest (GDOŚ, no date q).

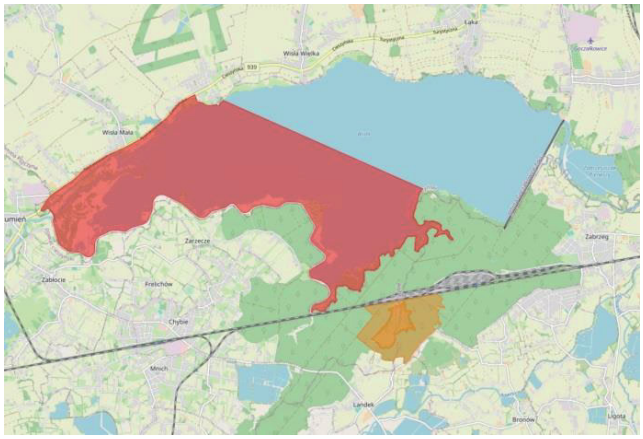

Fig. 6. The man-made Goczałkowice reservoir; the red colour marks Natura 2000 habitat site, the orange colour marks the strict nature reserve; source: own elaboration based on https://geoserwis.gdos.gov.pl/mapy

The Myczkowce dam

The Myczkowce dam (Fig. 7), constructed between 1956 and 1960, constitutes the lower stage of the San River cascade. The upper stage is Solina, the largest dam in Poland, built between 1961 and 1968. The Myczkowce dam is an earthen structure of 17.5 m in height, creating a reservoir of 200 ha. In the vicinity, several FoNC have been recorded, including three nature reserves, a Natura 2000 habitat area, and a protected landscape area. The first reserve, 'Nad Jeziorem Myczkowieckim', was established on 20 August 2003, covering an area of 164.25 ha (GDOŚ, no date o). The purpose of this reserve was to preserve the Berdo mountain ridge above Lake Myczkowieckie and its surrounding forests, which host numerous protected and rare

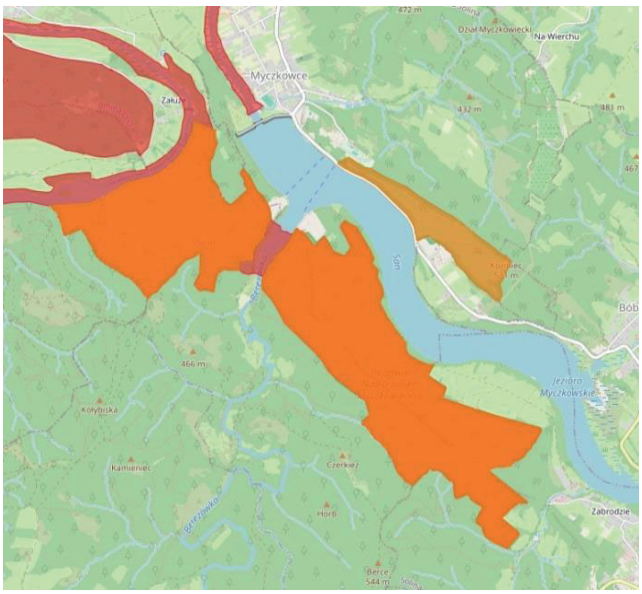

Fig. 7. The man-made Myczkowce reservoir; the red colour marks the Natura 2000 habitat site, the orange colour marks the strict nature reserve; source: own elaboration based on https://geoserwis.gdos.gov.pl/mapy

plant species in the undergrowth. The second reserve, 'Przełom Sanu pod Grodziskiem', was established on 4 September 2003, covering 100.59 ha (GDOŚ, no date p). Its purpose was to protect a portion of the San River valley, including the Grodzisko hill and its forests, home to several protected and rare plant species in the undergrowth. The third reserve, 'Koziniec', was established on 9 May 2004, and spans 28.76 ha (GDOŚ, no date n). The purpose of the reserve was to protect a section of the forested slope of Koziniec Mountain, featuring numerous rocky outcrops and habitats for rare plant species and xerothermic communities. The Natura 2000 site, 'Dorzecze Górnego Sanu', encompasses the upper part of the San River basin, its tributaries, and the left bank of the Myczkowce reservoir (GDOŚ, no date h). This site, established in January 2012, covers 1578.67 ha and is home to habitats for two invertebrate species, eight species of fish, and one mammal species, Eurasian otter (Tab. S2).

The Myczkowce and Solina Reservoirs are located within the Protected Landscape Area (Pol.: Wschodniobeskidzki Obszar Chronionego Krajobrazu) (GDOŚ, no date e), which serves as a buffer zone for the landscape parks of Słonne Mountains, Ciśniańsko-Wetliński area, and the San River Valley, surrounding the Bieszczady National Park.

The Orava dam

The Orava dam (Fig. 8), built in 1954 on the Orava River on the Czechoslovakian side (now Slovak Republic), is the largest artificial Slovak reservoir of 3,432 ha, capacity of 375 hm^3, and height of 15 m. Although it is situated in the Slovak Republic, the reservoir's backwater zone affects areas on the Polish side. The Czarna Orawa River, originating in Poland, flows into the reservoir. At its confluence, marshlands have formed, which in 2023 were designated as a Natura 2000 habitat protection area – 'Czarna Orawa' (GDOŚ, no date b). The protected area covers 465.66 ha and safeguards three fish species and one amphibian species, a fire-bellied toad (Tab. S2).

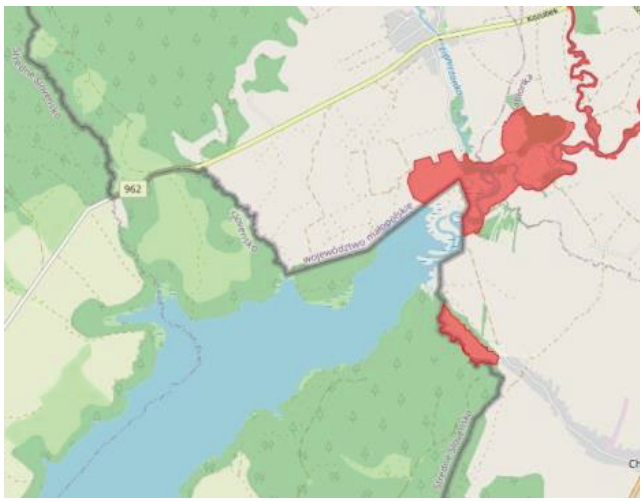

Fig. 8. The backwater of the man-made Orava reservoir; the Natura 2000 habitat site is marked red; source: own elaboration based on https://geoserwis.gdos.gov.pl/mapy

DISCUSSION

The research indicates that 79.3% of artificial water reservoirs are covered by at least one form of nature conservation. Nature reserves, which are among the most valuable forms of nature conservation (FoNC), have been established at six reservoirs, representing 10.3% of the total. Although takes a long time to establish protected areas after dam construction in Poland – on average of 47 years – these areas play a crucial role in safeguarding unique habitats and species of plants and animals important to the European Community. These areas play a crucial role in the conservation of fish species, such as the European bitterling (*Rhodeus amarus*) and European bullhead (*Cottus gobio*), amphibians including the fire-bellied toad (*Bombina bombina*) and great crested newt (*Triturus cristatus*), and semiaquatic mammals, including the Eurasian otter (*Lutra lutra*) and Eurasian beaver (*Castor fiber*). All of these species are currently assessed as Least Concern in the IUCN Red List of Threatened Species (ICUN, 2023). Additionally, these areas support a diverse range of waterfowl and provide important breeding refuges for bird species of interest to the European Community.

This perspective aligns with recent studies. Wu *et al.* (2019), reviewing 347 publications, examined the impact of dams on microorganisms, benthos, plankton, fish, aquatic mammals, botany, and birds. The authors found that dams have a dual effect: on one hand, they promote the development of many species, but on the other, they destroy existing wetlands such as rivers, lakes, and peat bogs, which are vital sources of biological diversity. However, dams also create new wetlands, contributing to increased richness and diversity of fauna and flora. Koutsos, Dimopoulos, and Mamolos (2010) assessed that constructing a new dam on the Marmaras River would have a positive impact on the vast majority of species downstream of the Natura 2000 area. This challenges the commonly belief that dams solely interfere with environmental protection, causing irreversible damage (Tullos, Tilt and Liermann, 2009). Similarly, a study on the Slovak Gabcikovo hydroelectric power plant analysed satellite images from 1988 to 1997 to evaluate changes in the original riverbed and surrounding vegetation. The authors concluded that the Danube River diversion caused no significant environmental changes in the region.

It is important to note that harmful substances such as metals and phosphorus are retained in artificial reservoirs in the form of sediments (Kostecki, 2022). This sedimentation process is a positive effect of artificial reservoirs on ecological status of downstream river valleys.

The seven case studies of dams – Mietków, Turawa, Dychów, Jeziorsko, Goczałkowice, Myczkowce, and Orava – clearly demonstrate that the valuable protected areas found on and around artificial reservoirs have emerged solely as a result of dam construction. These protected areas safeguard unique habitats and species of plants and animals that are important to the European Community. These include at least 103 bird species (Tab. S1), and total of 21 species of invertebrates, fish, amphibians, and mammals (Tab. S2) of European conservation interest.

As mentioned earlier, the research focused on large dams. It would be advisable to carry out similar studies for smaller dams, with heights between 5 and 15 m and capacities starting from $3{\cdot}10^6$ m^3, as well as on very small dams less than 5 m high. A particular category of small dams includes headwater lakes, where a small dam at the lake outflow raises the water level. The exact number of headwater lakes in Poland is currently not known, and the environmental impact of their impoundment remains unclear. It is expected that small artificial water reservoirs and headwater lakes provide habitats supporting a high diversity of fish, amphibians, birds, and semiaquatic mammals.

This study includes only artificial reservoirs where forms of nature conservation have already been established. However, this does not mean that other reservoirs lack positive environmental impacts. For example, the Dobczyce reservoir on the Raba River features a 30-metre-high dam with a capacity of $127{\cdot}10^6$ m^3, built in 1986. Baran (2006) documented 226 bird species in the reservoir area.

The studies reviewed demonstrate that dams offer numerous environmental benefits, challenging the predominantly negative portrayal often found in mainstream sources (International Rivers, no date). While this review does not advocate for building dams in areas of high natural value, it underscores the essential role of water as a life-sustaining resource on our planet. In many regions, water availability is not vital for improving living standards but also critical for the survival of local communities (Boyé and Vivo, 2016). The shortage of water has led to numerous conflicts in human history, with 1,634 incidents reported (Pacific Institute, 2023). For instance, Seliktar (2005) argues that control over the Jordan River's water resources was a covert factor in triggering the 1967 Six-Day War. The demand for freshwater – for drinking and irrigation – is expected to increase due to population growth and climate change. However, freshwater resources are limited and unevenly distributed. The construction of dams and the accumulation of water in artificial reservoirs ensures equitable and universal access to water. Therefore, the social acceptability of dams is of paramount importance (Seliktar, 2005).

One challenge in reliable research on the impact of artificial reservoirs on ecosystems is the prevailing focus on demonstrating their harmful effects. Often, the opposite conclusion – that reservoirs can have beneficial impacts – is an unintended finding. For example, Szczęsny (1995) reported that the construction of the Niedzica-Sromowce reservoir complex on the Dunajec River significantly disturbed benthic invertebrate populations. How-

ever, the greatest population decline occurred following the flood in November 1992. From this, one can infer that by mitigating flood effects, dam construction actually supports the development of invertebrate fauna.

CONCLUSIONS

The research reveals that approximately 80% of artificial reservoirs in Poland created by large dams are associated with at least one form of nature conservation, and 17% have three of more forms. Areas of protected landscape are the most common, present at approximately 59% of the reservoirs, followed by landscape parks, Natura 2000 Habitat Directive areas, and Natura 2000 Bird Directive areas. The wet backwater zones of reservoirs provide valuable habitats, especially for birds. Overall, artificial reservoirs support numerous rare and protected animal species, including at least 103 bird species listed in Annex I and II of the Bird Directive, as well as 11 fish species, 3 amphibian species, and 2 mammal species listed in Annexes II and IV of the Habitat Directive.

Dams and artificial reservoirs, like all human activities, inevitably impact the natural environment. However, unlike factories or industrial plants, dams collect and store life-giving water, providing a form of natural compensation for environmental losses. Artificial reservoirs support the development of many species.

SUPPLEMENTARY MATERIAL

Supplementary material to this article can be found online at: https://www.jwld.pl/files/Supplementary_material_67_Opyrchal.pdf.

CONFLICT OF INTERESTS

All authors declare that they have no conflict of interests.

REFERENCES

Baran, M. (2006) "Ptaki Zbiornika Dobczyckiego (1986–2006). Różnorodność, liczebność, rozmieszczenie i ochrona [Birds of the Dobczyce Reservoir (1986–2006). Diversity, abundance, distribution, and conservation]," in A. Bokwa and M. Malinowski (eds.) *Ekoturystyka szansą rozwoju gmin wokół Zbiornika Dobczyckiego [Ecotourism as a development chance for the communities located around the Dobczyce water reservoir]*. Dobczyce: Urząd Gminy i Miasta Dobczyce, pp. 79–102.

Boyé, H. and Vivo de, M. (2016) "The environmental and social acceptability of dams," *Field Actions Science Reports*, *Environmental and social acceptability of major industrial projects: from risk management to shared prosperity*, special issue 14, pp. 32–37. Available at: http://journals.openedition.org/factsreports/4055 (Accessed: December 30, 2023).

Brzeziński, M., Chibowska, P. and Romanowski, J. (2013) "Dam reservoir affects diet of otters inhabiting mountain river in SE Poland," *Folia Zoologica*, 62(1), pp. 54–58. Available at: https://doi.org/10.25225/fozo.v62.i1.a8.2013.

Council Directive (1992) "Council directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora," *Official Journal*, L 206, consolidated version 1.1.2007. Available at: https://eur-lex.europa.eu/eli/dir/1992/43/oj/eng (Accessed: December 30, 2023).

Czerniawski, R. *et al.* (2010) "Wpływ małej zapory na zmiany składu ichtiofauny w cieku Sitna w ciągu 9 lat (otulina Drawieńskiego Parku Narodowego) [Impact of small dam on changes of fish fauna in Sitna Stream during period of nine years (buffer zone of Drawieński National Park)], *Rocznik Ochrony Środowiska*, 12(1), pp. 235–247. Available at: https://www.ros.edu.pl/images/roczniki/archive/pp_2010_012.pdf (Accessed: December 30, 2023).

Directive (2009) "Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds," *Official Journal*, L 20/7. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:020:0007:0025:en:PDF (Accessed: December 30, 2023).

GDOŚ (no date a) *Centralny Rejestr Form Ochrony Przyrody [Central Register of Nature Protection Forms]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/ (Accessed: November 23, 2023).

GDOŚ (no date b) *Centralny Rejestr Form Ochrony Przyrody. Obszar Natura 2000. Czarna Orawa [Central Register of Nature Protection Forms. Natura 2000 Area. Czarna Orawa]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/widok/viewnatura2000.jsf?fop=PL.ZIPOP.1393.N2K.PLH120002.H (Accessed: November 21, 2023).

GDOŚ (no date c) *Formularz danych dla obszaru chronionego krajobrazu. Nadwarciański Park Krajobrazowy [Data form for a protected landscape area. Nadwarciański Park Krajobrazowy]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.PK.100.pdf (Accessed: November 23, 2023).

GDOŚ (no date d) *Formularz danych dla obszaru chronionego krajobrazu. Uniejowski [Data form for a protected landscape area. Uniejowski]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.OCHK.136.pdf (Accessed: November 23, 2023).

GDOŚ (no date e) *Formularz danych dla obszaru chronionego krajobrazu. Wschodniobeskidzki Obszar Chronionego Krajobrazu [Data form for a protected landscape area. Wschodniobeskidzki Obszar Chronionego Krajobrazu]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.OCHK.184.pdf (Accessed: November 23, 2023).

GDOŚ (no date f) *Formularz danych dla obszaru Natura 2000. Dolina Dolnego Bobru [Data form for the Natura 2000 area. Dolina Dolnego Bobru]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.N2K.PLH080068.H.pdf (Accessed: November 23, 2023).

GDOŚ (no date g) *Formularz danych dla obszaru Natura 2000. Dolina Górnej Wisły [Data form for the Natura 2000 area. Dolina Górnej Wisły]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.N2K.PLB240001.B.pdf (Accessed: November 23, 2023).

GDOŚ (no date h) *Formularz danych dla obszaru Natura 2000. Dorzecze Górnego Sanu [Data form for the Natura 2000 area. Dorzecze Górnego Sanu]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.N2K.PLH180021.H.pdf (Accessed: November 23, 2023).

GDOŚ (no date i) *Formularz danych dla obszaru Natura 2000. Zbiornik Goczałkowicki – Ujście Wisły i Bajerki [Data form for the Natura*

2000 area. Zbiornik Goczałkowicki – Ujście Wisły i Bajerki]. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.N2K.PLH240039.H.pdf (Accessed: November 23, 2023).

GDOŚ (no date j) *Formularz danych dla obszaru Natura 2000. Zbiornik Jeziorsko [Data form for the Natura 2000 area. Zbiornik Jeziorsko]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.N2K.PLB100002.B.pdf (Accessed: November 23, 2023).

GDOŚ (no date k) *Formularz danych dla obszaru Natura 2000. Zbiornik Mietkowski [Data form for the Natura 2000 area. Zbiornik Mietkowski]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.N2K.PLB020004.B.pdf (Accessed: November 23, 2023).

GDOŚ (no date l) *Formularz danych dla obszaru Natura 2000. Zbiornik Turawa [Data form for the Natura 2000 area. Zbiornik Turawa]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.N2K.PLB160004.B.pdf (Accessed: November 23, 2023).

GDOŚ (no date m) *Formularz danych dla rezerwatu przyrody. Jeziorsko [Nature reserve data form. Jeziorsko]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.RP.710.pdf (Accessed on 23.11.2023).

GDOŚ (no date n) *Formularz danych dla rezerwatu przyrody. Koziniec [Nature reserve data form. Koziniec]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.RP.1092.pdf (Accessed: November 23, 2023).

GDOŚ (no date o) *Formularz danych dla rezerwatu przyrody. Nad Jeziorem Myczkowieckim [Nature reserve data form. Nad Jeziorem Myczkowieckim]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.RP.1102.pdf (Accessed: November 23, 2023).

GDOŚ (no date p) *Formularz danych dla rezerwatu przyrody. Przełom Sanu pod Grodziskiem [Nature reserve data form. Przełom Sanu pod Grodziskiem]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.RP.1103.pdf (Accessed: November 23, 2023).

GDOŚ (no date q) *Formularz danych dla rezerwatu przyrody. Rotuz [Nature reserve data form. Rotuz]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.RP.241.pdf (Accessed: November 23, 2023).

GDOŚ (no date r) *Formularz danych dla stanowiska dokumentacyjnego. Siedlątków [Data form for the documentation station. Siedlątków]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://crfop.gdos.gov.pl/CRFOP/download/pdf/PL.ZIPOP.1393.SD.31.pdf (Accessed: November 23, 2023).

GDOŚ (no date s) *Formy ochrony przyrody [Forms of nature conservation]*. [Online]. Generalna Dyrekcja Ochrony Środowiska. Available at: https://www.gov.pl/web/gdos/formy-ochrony-przyrody (Accessed: November 26, 2023).

Głowacki, Ł. *et al.* (2011) "Effects of damming a large lowland river on chironomids and fish assessed with the (multiplicative partitioning of) true/Hill biodiversity measure," *River Research and Application*, 27(5), pp. 612–629. Available at: https://doi.org/10.1002/rra.1380.

International Commission On Large Dams (no date) *Definition of a large dam*. Available at: https://www.icold-cigb.org/GB/dams/definition_of_a_large_dam.asp (Accessed: November 27, 2023).

International Rivers (no date) *Environmental impacts of dams*. Available at: https://archive.internationalrivers.org/environmental-impacts-of-dams (Accessed: November 22, 2023).

IUCN (2023) *Red List of Threatened Species*. International Union for Conservation of Nature. Available at: https://www.iucnredlist.org/ (Accessed: December 10, 2023).

Koutsos, T.M., Dimopoulos, G.C. and Mamolos, A.P. (2010) "Spatial evaluation model for assessing and mapping impacts on threatened species in regions adjacent to Natura 2000 sites due to dam construction," *Ecological Engineering*, 36, pp. 1017–1027.

Mazierski, J. and Kostecki, M. (2021) "Impact of the heated water discharge on the water quality in a shallow lowland dam reservoir," *Archives of Environmental Protection*, 47(2), pp. 29–46. Available at: https://doi.org/10.24425/aep.2021.137276.

Milliman, J.D. (1997) "Blessed dams or damned dams," *Nature*, 386, pp. 325–327. Available at: https://doi.org/10.1038/386325a0.

Olszamowski, Z. and Rożnowska, L. (1988) *Monografia zbiornika wodnego Wisła-Czarne [Monograph of the Vistula-Czarne water reservoir]*. Warszawa: Wydawnictwa Geologiczne.

Pacific Institute (2023) *Water war chronology*. Available at: https://www.worldwater.org/conflict/list/ (Accessed: December 30, 2023).

Penczak, T., Głowacki, Ł. and Galicka, W. (1998) "A long-term study (1985–1995) of fish populations in the impounded Warta River, Poland," *Hydrobiologia*, 368, pp. 157–173. Available at: https://doi.org/10.1023/A:1003246115666.

Pietrucha-Urbanik, K. and Rak, J. (2023) "Water, resources, and resilience: Insights from diverse environmental studies," *Water*, 15, 3965. Available at: https://doi.org/10.3390/w15223965.

Sedláček, J. *et al.* (2022) "A closer look at sedimentation processes in two dam reservoirs," *Journal of Hydrology*, 605. Available at: https://doi.org/10.1016/j.jhydrol.2021.127397.

Seliktar, O. (2005) "Turning water into fire: the Jordan River as the hidden factor in the six day war," *The Middle East Review of International Affairs*, 9(2), pp. 57–71.

Smith, S.E. *et al.* (2000) "Environmental impact of river diversion: Gabcikovo barrage system," *Journal of Water Resources Planning and Management*, 126(3), pp. 138–145.

Szczęsny, B. (1995) "Degradacja fauny bezkręgowców bentosowych Dunajca w rejonie Pienińskiego parku narodowego [Degradation of the benthic invertebrate fauna of the Dunajec River of Pieniny National Park area (Southern Poland)]," *Ochrona Przyrody*, 52, pp. 207–224.

Tullos, D., Tilt, B. and Liermann, C. (2009) "Introduction to the special issue: Understanding and linking the biophysical socioeconomic and geopolitical effects of dams," *Journal of Environmental Management*, 90, pp. 203–207. Available at: https://doi.org/10.1016/j.jenvman.2008.08.018.

Ustawa (2004) "Ustawa z dnia 16 kwietnia 2004 r. o ochronie przyrody [Act of April 16, 2004, on Nature Conservation]," *Dz.U.*, 2004, 92 poz. 880. Available at: https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20040920880/U/D20040880Lj.pdf (Accessed: December 30, 2023).

Wołos, A. and Wiśniewolski, W. (2009) "Fish stock assessment in dam reservoirs located in the upper Vistula and Warta river catchment areas based on angling catch records," *Archives of Polish Fisheries*, 17, pp. 53–64. Available at: https://doi.org/10.2478/v10086-009-0003-2.

Wu, H. *et al.* (2019) "Effects of dam construction on biodiversity: A review," *Journal of Cleaner Production*, 221, pp. 480–489. Available at: https://doi.org/10.1016/j.jclepro.2019.03.001.