Can a tragic war event provide ecological benefits to threatened fish species?

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Key points

The Nova Kakhovka Dam destruction was a tragic event with societal, economic and environmental consequences

This tragic event may nevertheless represent an opportunity to manage towards promoting freshwater habitats and species

Not rebuilding could allow large-scale ecological restoration and enhancement of longitudinal connectivity in the lower Dnieper

Abstract

Since ancient times water has been part of conflicts, either as a trigger, a weapon or a casualty. On the 6th of June 2023, the Nova Kakhovka Dam was destroyed as a consequence of the Russian-Ukrainian conflict. Environmentally, this catastrophe poses multiple challenges, however, it may also lead to an effective reconnection of a considerable portion of the lower Dnieper River network (360% increase in river length and 2.5-fold increase in river connectivity), benefiting 17 economically important diadromous, 27 potamodromous and 15 resident fish species. During World War II, the "Lenin Dam" near Zaporizhzhya was destroyed twice, in 1941 and 1943, being reconstructed afterwards. This may indicate a future reconstruction of the Nova Kakhovka Dam, but not rebuilding could represent an opportunity for large-scale ecological restoration and enhancement of longitudinal connectivity in the lower Dnieper. It could be an unprecedented reconnection of a European large river favouring habitats belonging to the Pan-European network of protected sites (the Emerald Network) and over 50 freshwater fish species. To achieve this, alternative solutions to the Dnieper cascade should be found, one that ideally maintains the provisioning of Ecosystem Services and safeguards the needs and security of the human population without the Nova Kakhovka dam reconstruction.

Data Statement

Data was made available at the Open Science Framework platform (see Duarte, G. & Branco, P. 2023. The Open Science Framework. DOI:10.17605/OSF.IO/AGCK4). The River Network Toolkit is a freely available Software (http://rivtoolkit.com/), the version used is currently under testing and thus available by request.

Plain Language Summary

Freshwater facilities are common casualties during armed conflicts, and the Russian-Ukraine war is no exception. So far, the most pervasive war action involving the use of a freshwater infrastructure was the destruction of the Nova Kakhovka Dam, constituting an economic, societal and environmental catastrophe of great proportions. The Dnieper cascade of reservoirs and dams is responsible for the current degraded ecological state of freshwater habitats and the decline and extinction of native freshwater species, especially for diadromous fish species. As such, this tragic event may present a unique opportunity for management towards freshwater fish species conservation and river connectivity in the lower Dnieper.

Keywords

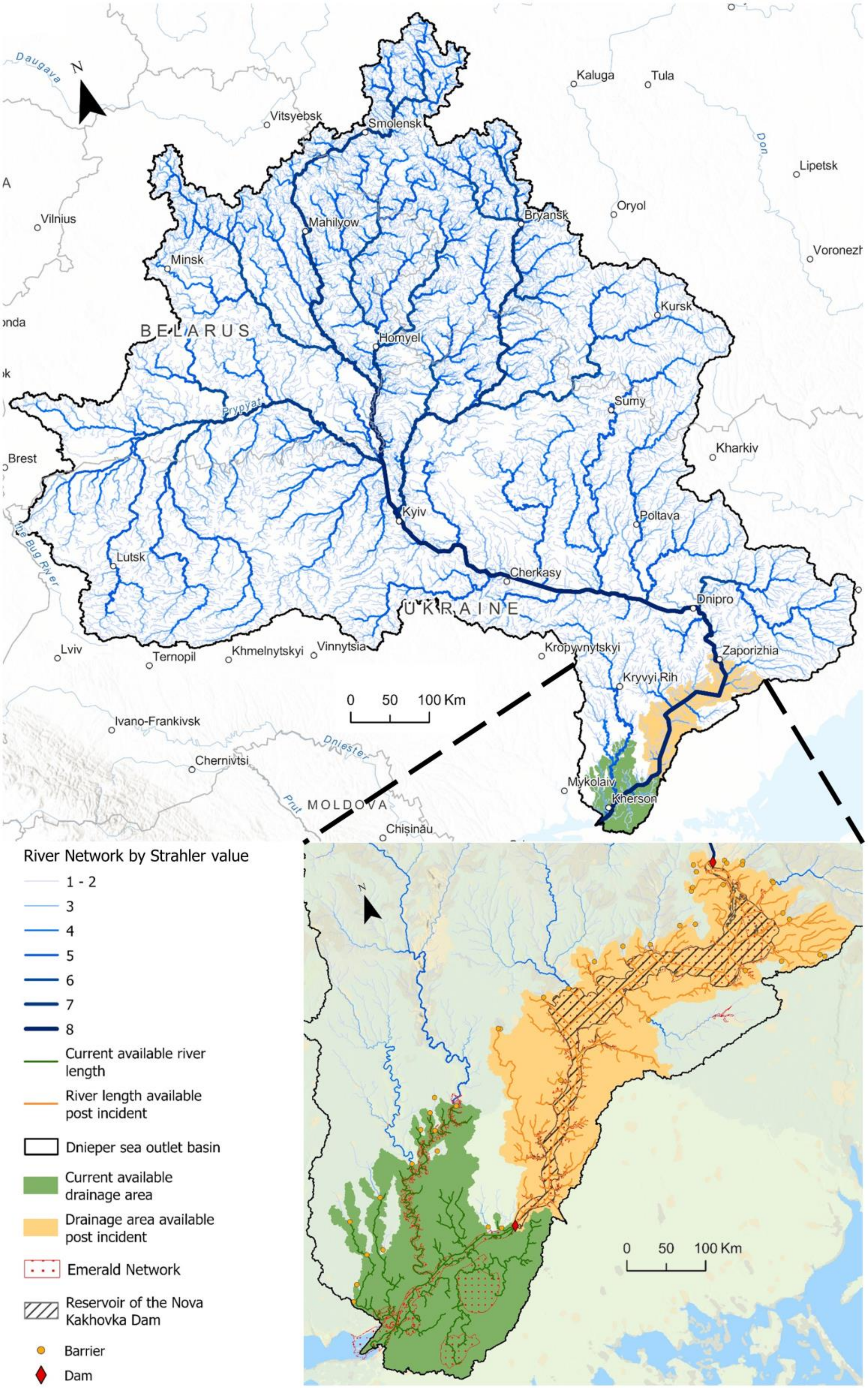
River network connectivity, Dam destruction, Diadromous fish, War conflict, Dnieper

Commentary

Wars have always impacted the environment. Freshwaters are among the most vulnerable resources and environments during conflicts. Water has been, since 2500 BC, part of conflicts, either as a trigger of conflicts, as a weapon or as a casualty of war (R. A. Francis, 2011). There are 3 main reasons for water to be at the centre stage of armed conflicts (R. A. Francis, 2011): 1) their positioning – often at the geographical centre of wars; 2) their structure – riverscape connectivity and network nature (longitudinal, lateral and hyporheic) means that impacts can be transmitted across the network, not affecting only point of impact; and 3) difficulty of recovery – freshwater systems are particularly hard to restore to previous conditions, so war-related impacts may have long-lasting effects (Dufour & Piégay, 2009; R. Francis, 2009; Gore & Shields, 1995). The present war between Russia and Ukraine is characterized, among other things, as taking place in a region with a highly modified water sector (Shumilova et al., 2023), particularly along the Dnieper River, one of the largest river basins in Europe. Adding to the high concentration of human settlements along the Dnieper River, it also contains large water reservoirs created by large dams that are responsible for hydropower, agriculture and cooling of nuclear power plants (Shumilova et al., 2023). During the Russia-Ukraine war, water infrastructures have been used by both sides as part of their defensive and offensive war strategies (Gleick et al., 2023). On the 6th of June 2023, the Nova Kakhovka Dam in Ukraine was destroyed, resulting in the loss of Human lives and the displacement of tens of thousands of people due to the destruction of several important infrastructures, including houses and roads. Moreover, the reservoir provided water for more than 700,000 people in south Ukraine. Cities on the Dnieper River, including Kherson, Nikopol, Marhanets and Pokrov, are according to the United Nations, suffering water scarcity (Naddaf, 2023). Immediate impacts are also affecting around 160,000 animals, some of which are rare and/or endangered, such as the vulnerable Nordmann's birch mouse (*Sicista loriger*) and the endangered sand mole rat (*Spalax arenarius*) (Naddaf, 2023).

Waterbourne species are arguably the most affected by any instream structure, and for fish, this is particularly relevant because habitats important for their life cycle are usually spatially and/or temporally separated. The Nova Kakhovka Dam played an important role in fragmenting the river network of the Dnieper basin (Vasil Eva, 2003). This dam created a water storage reservoir that occupied 2,098 Km^2, blocking access to 243.4 Km of the Dnieper River and directly altering approximately 694 linear Km (when including tributaries) of riverine habitats. The current ecological status of the Dnieper is significantly defined by the creation and functioning of the cascade of reservoirs and respective dams (Kovalenko & Goncharuk, 2019). Furthermore, the impacts of these infrastructures along with direct and indirect related human activities have been clearly linked to the decline and extinction of native freshwater species (Kovalenko & Goncharuk, 2019; Vasil Eva, 2003) and the introduction of freshwater alien species (Vasil Eva, 2003). For instance, the absence of natural reproduction of the Beluga (*Huso Huso*), the Russian Sturgeon (*Acipenser gueldenstaedtii*) and the Stellate sturgeon (*Acipenser stellatus*) in the Dnieper have been linked to the lack of spawning grounds caused by damming and excessive flow regulation (Demchenko et al., 2021). More specifically, the decline in the abundance and the loss of breeding sites of the Beluga Sturgeon have been associated with the construction of the Kakhovka Dam (Vasil Eva, 2003).

Multiple authors have expressed their concern over the societal, health, economic and environmental impacts of the destruction of the Nova Kakhovka Dam (Gleick et al., 2023; Holt, 2023; Kitowski et al., 2023; Shumilova et al., 2023; Vyshnevskyi et al., 2023). In the short term, environmentally, this catastrophe poses multiple challenges, for instance, due to the large movements of sediment (Hart et al., 2002), especially those contaminated with industrial waste (Naddaf, 2023), severe hydrologic alterations and habitat loss downstream (Hart et al., 2002). One of the first published assessments already revealed biological and chemical alterations in the water from the lower Dnieper River to the river mouth and surrounding coastal areas of the Black Sea (Vyshnevskyi et al., 2023). These authors have registered phytoplankton increase, high concentrations of nitrogen and phosphorus compounds and concentrations of life-threatening chemicals (e.g., zinc, copper, arsenic, cadmium) significantly above the permissible limits. Even though these negative consequences, the destruction of the Nova Kakhovka Dam also presents an opportunity to permanently reconnect the lower Dnieper (Figure 1), which will bring positive ecological impacts to an area included in the Pan-European network of protected sites, the Emerald Network (https://emerald.eea.europa.eu). When considering the full removal of the reservoir and protection levees, this may increase significantly the length of the network available for 17 economically important diadromous fish species, six of which are endangered (*Anguilla anguilla*, *Acipenser ruthenus*, *Acipenser gueldenstaedtii*, *Acipenser stellatus*, *Huso huso* and *Alosa immaculata*). In addition, it could also benefit 27 potamodromous species (two endangered: *Cyprinus carpio* and *Alburnus sarmaticus*) and 15 resident species of freshwater fish. Under this scenario of reconnection (Figure 1): i) the Dnieper River network connectivity for diadromous fish (measured by the Dendritic Connectivity Index for Diadromous (Cote et al., 2009) would have a 2.5-fold improvement, from 0.00745 to 0.02655 (calculations made using the River Network Toolkit (Duarte et al., 2019)); and ii) Diadromous fish that now have 827.7 km of rivers to spawn and live, would benefit from an increase of 2978.6 km (a 360% increase) in their river network availability corresponding to an overall 3,806 km of river and 18,215 km^2 of drainage area directly connected with the Black sea (for data used in this analysis please see Duarte and Branco (2023)).


Daugava
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BELARUS
Homyel
Prypyat
Sumy
Brest
Kharkiv
Kyiv
Poltava
Lutsk
Cherkasy
Dnipro
UKRAINE
Lviv
Ternopil
Khmelnytskyi
Vinnytsia
Kropyvnytskyi
Zaporizhia
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Dniester
Chernivtsi
Mykolaiv
Kherson
Prut
MOLDOVA
Chișinău
River Network by Strahler value
1 - 2
3
4
5
6
7
8
Current available river length
River length available post incident
Dnieper sea outlet basin
Current available drainage area
Drainage area available post incident
Emerald Network
Reservoir of the Nova Kakhovka Dam
Barrier
Dam
0 50 100 Km

Figure 1 – Representation of the Dnieper River network basin (top) with a detailed illustration (bottom) of the river network and respective drainage area related to the Nova Kakhovka Dam. Green areas indicate the drainage area of the segments (in green) that were available for diadromous fish species below this dam. Orange areas indicate the drainage area of the segments (in orange) that may become permanently available for diadromous fish species migration if the dam is not rebuilt. Areas included in the Pan-European network of protected sites (the Emerald Network) were illustrated using red dots (obtained at https://emerald.eea.europa.eu). The river network of segments and the sea outlet basin were taken from the Catchment Characterisation Model (CCM2) database (De Jager & Vogt, 2007). Dam locations were taken from the GlObal geOreferenced Database of Dams (GOODD) (Mulligan et al., 2020) and confirmed using the Georeferenced global Dams And Reservoirs (GeoDAR) dataset (Wang et al., 2022) from where the Nova Kakhovka Dam reservoir was also taken. Barrier locations were obtained by manual digitization using ESRI® World Imagery. All data used and obtained is available on the Open Science Framework platform (Duarte & Branco, 2023).

Studies made so far have assessed the impacts and documented the environmental short-term consequences of this war event (Gleick et al., 2023; Shumilova et al., 2023) while debating and questioning if the infrastructure should be rebuilt (Kitowski et al., 2023; Stone, 2023). Beyond the electricity production, the Kakhovka dam provided water supply for multiple cities (Bulakh, 2020) across three administrative regions (with over 5.7 million habitants according to the Ukraine state statistics service – www.ukrstat.gov.ua) while allowing the irrigation of 350 000 ha of arable land (Vyshnevskyi et al., 2023). The dam played an additional role by providing water supply to large industrial facilities, including the Zaporizhzhia nuclear power plant (Vyshnevskyi et al., 2023). It was, nonetheless, considered to be oversized, inefficient for electric production and poorly planned in terms of water management (Vyshnevskyi et al., 2023). In Europe, dam removal is defined as a cornerstone tool for river restoration to achieve the goal of restoring 25 000 km of river to free-flowing status (ref EU 2030 strategy). Moreover, Ukraine has also committed to the recommendations of the Pan-European Sturgeon Conservation Action Plan where goals include the "restoration of habitats in key rivers" and that "no barriers to sturgeon migration in key rivers are created" (Demchenko et al., 2021). In 2022, a new record number of dam removals occurred across 16 European countries, including Ukraine, but most removals were of small structures, not located in the main stem segments of large river networks (Mouchlianitis, 2023). An exception was the removal of a large dam in the Sélune River, following a previous 2020 removal of another large dam, making accessible more than 60 km of this river (not including tributaries) for several migratory diadromous fish species (Mouchlianitis, 2023). For comparison, the destruction of the Nova Kakhovka dam made accessible over 240 km of the Dnieper River (not including tributaries) for migratory diadromous fish species. The removal of large dams has significant ecological upside for freshwater ecosystems and biodiversity, a benefit that the Elwha River dam removals have proved in the last few years (Hess et al., 2021; Quinn et al., 2017; Tonra et al., 2015).

Ukraine is no stranger to dam catastrophes, particularly the lower Dnieper. During the Second World War, in 1941, the “Lenin Dam” near Zaporizhzhya was destroyed by Stalin’s secret police to avoid German troops' incursion into Ukraine (at the time part of the Soviet Union). Similarly to current events, the explosion of the dam resulted in flooded villages and the death of up to 100,000 people. The dam was swiftly reconstructed in 2 years, but in 1943 it was again blown, this time by the German troops while being forced out of Ukraine by the Soviet Army (Adamo et al., 2021). After the war, the dam was finally reconstructed and electric production came to fruition in 1950 (Adamo et al., 2021). This historical praxis may prelude to a future reconstruction of the Nova Kakhovka Dam. Concomitantly, in a recent work, Vyshnevskyi et al. (2023) argue towards the reconstruction of the dam, without discussing the ecological and river network connectivity upside of not rebuilding it. Other authors entice a more open debate, sharing opinions from multiple experts. These range from those who think that not reconstructing the dam would be disastrous, those who argue building it differently to avoid past ecological impacts, and others who think no rebuilding should be done (Stone, 2023). Even before the war, this lower Dnieper area had already been identified as having excellent potential for large-scale ecological restoration (Stone, 2023). Here we have shown the overwhelming scale in terms of the restoration of longitudinal connectivity if the no-rebuild option prevails. This groundbreaking reconnection of a fragmented system could provide endangered migratory fish species with additional habitats and create the possibility of a significant environmental improvement in the lower Dnieper. But, for this to be a reality, an alternative solution for the hydraulic structure of the Dnieper cascade should be found, one that ideally maintains the provisioning of Ecosystem Services, especially for the administrative regions favoured by the destroyed dam, while safeguarding human population security and needs without the Nova Kakhovka dam reconstruction.

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