Dnipro River Integrated Vision

Інтегрована Візія Річки Дніпро

rozkvit GREENPEACE

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Introduction

Contents

Introduction

The Dnipro River is essential for Ukraine. Ukraine is incomplete with the Dnipro River.

The Dnipro River is like a golden thread connecting the past with the present and with the future. The Dnipro River is about life: the life of microorganisms, plants, and animals, and the life of humans. But also the lives of societies, nations, and countries. And at the same time, the Dnipro River is about risks and threats. It is both under threat and a threat itself, putting all life that depends on it at risk. It is weaponised by the war, it is put in danger as a result of the war, and at the same time, it is a necessary and unavoidable element for liberation and peace. Put in a more concrete way, three Sustainable Development Goals (SDGs) are tightly connected to the Dnipro River Basin: Clean water and sanitation (SDG6), Sustainable cities and communities (SDG11) and Climate action (SDG13). But, as our report will show, much more is at stake, espcially in the context of war.

Soon after the full-scale invasion began, Greenpeace launched a series of initiatives for a new kind of reconstruction in Ukraine. Turning a small, damaged hospital into a green prototype for the process led to the ambition to scale up and develop a concept for greening an entire city, region or even something specific like a river basin.

At the same time, at the beginning of 2023, Ro3kvit was seriously considering a study of the importance and impact of the Dnipro River, in all its complexity. The russian terrorist destruction of the Kakhovka Dam and the ensuing humanitarian, economic and ecological consequences served as an extra trigger, pushing us to embark on this project.

In the summer of 2023, Greenpeace and Ro3kvit teamed up to unite experience and expertise to develop strategies and visions that would help address the existing challenges and reveal the unused potential of the Dnipro River. What can be better than the country's largest river in demonstrating how a green, climate-friendly future for Ukraine can be developed?

This vision can be seen as a combination of research, scenarios, and ideas proposed to a broad audience: planners, policymakers, experts in different fields, and the general population. It is a compilation of facts and experiences from the past and present, an analytical work proposed for consideration in discussing future opportunities for the Dnipro River. How exactly those opportunities should be realised is open for discussion. Much like the questions, where to start from and when? Understandably, as the war continues, many things seem less evident, irrelevant, untimely, and too complex. But the discussion should start sooner or later. We believe this work can be helpful in setting the ground for finding the path to a better future that uncovers the full potential of the Dnipro River.

Our Dnipro River Integrated vision connects different topics, or as we like to call them – layers. By connecting and superposing the various social, cultural, natural, economic and other layers, we are able to expose how different configurations of interventions lead to positive or negative impacts. In some places, layers efficiently coexist, on other instances, conflicts seem inevitable, requiring us to rethink the complex network and find alternative solutions. Usually, the best-integrated design tries to include as many different layers and goals as possible without harming other outcomes significantly. This is what we try to achieve for the Dnipro River. What makes this even more complex is scale. Working with the Dnipro River inevitably requires connecting different scales, from national to regional and to local dimensions, as well as from the river to the basin – from water to land.

Ultimately, what this report attempts to do is also to bridge the gap between those scales, but also between people. By presenting the various topics, we aim to reveal these diverse perspectives of looking at the Dnipro River, encouraging the different actors and stakeholders to try to understand each other better, in order to reach better solutions together.

Report Structure

In ***Part 1***, we describe the context of the Dnipro River. We start with the physical geography, introducing the reader to general characteristics of the river. We continue with a detailed historical overview of our human interaction with the river through the centuries and millenia and the transformations the Dnipro River has gone through. We conclude with a discussion of the current political and legal contexts.

In ***Part 2***, we focus on the values of the Dnipro, describing the main functions that the river performs in the current context of Ukraine (before the full-scale invasion in February 2022). Just as in the past, the Dnipro River is a source of life in various aspects: from the water it supplies for general population needs, to agriculture, industry, electricity generation, transportation, as well as tourism and recreation. Finally, the Dnipro River is an integral element of Ukraine's cultural heritage and identity.

Part 3 brings us back to the current realities. The Dnipro River is the front line. The Dnipro River is under attack. Here, we explore the impact of war hostilities on Ukraine's main waterway, including the destruction of the Kakhovka Dam. We also look at broader risks and threats related to energy insecurity, water pollution, and other developments affecting the economic and social situation in the country.

Part 4 turns our attention to the future. Here we come again to the same different layers described in the previous chapters, but now offering recommendations and visions for each layer on how we would like to see the river in the future. ***Part 5*** consolidates the above proposals, combining them into an integrated list of fundamental principles for the future development of the Dnipro River. We also propose to consider three scenarios, in order to assess the interrelationships between the layers and what combinations might be most relevant today.

Part 6 places the recommendations from Chapters 4 and 5 in a specific local urban context, namely the city of Kremenchuk, on the banks of the Dnipro River, for a more concrete and clearer understanding. ***Part 7*** considers the question of whether the Kakhovka HPP and dam should be restored based on the information presented in the previous chapters. Finally, in ***Part 8*** we provide recommendations for the next steps, including information about Integrated water management, river basin management plans, and participative approaches.

This study is only a first step, and there is still much work to be done. We hope that the research, strategies and suggestions will provide new knowledge, inspiration and open the door for further steps.

Report contents

Project team

Core Team

Fulco Treffers	Team lead, Urban planning, Overall strategy	Chapters 0, 4, 5, 7, 8
Antoine Korchagin	Research, Structure, Design, Layout	Chapters 0, 1, 2, 3, 4, 7
Svitlana Usychenko	Research, Urban design, Mapping, Diagrams, Layout	Chapters 2, 6, 7
Vaagn Mnatsakanian	Strategy, Agriculture, Environment, Energy	Chapters 2, 4, 7
Tim Van Epp	Strategy, Water management, Editing	Chapters 3, 4, 8
Niall Buckley	Kremenchuk Energy Modelling	Chapter 6
Hristo Panchev	Research, Strategy, Energy	Chapters 2, 3, 4, 6
Angel Bondov	Research, Biodiversity, Mapping	Chapters 2, 3, 4

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Anastasia Anoshima	Translation

Stakeholders

Main Stakeholders

The Dnipro River is so large and important to so many individuals, communities, enterprises, sectors, that finding ways in which all its various dimensions and interests are adequately represented is a huge challenge. The scope of our research inevitably made it difficult to capture all the different dimensions of the Dnipro River. Some of it had been deducted and analysed from articles, reports, books and other publications.

For those topics which seemed most important to us, however, we had an opportunity to interact more closely with various stakeholders to gain a more in-depth understanding of their views, opinions, expertise about the Dnipro River. We especially would like to mention here the main partners Ecoaction, the State Agency of Water Resources of Ukraine and the Kremenchuk municipality.

We want to express our gratitude to all those people that contributed to this research either by providing information, answering our questions, agreeing to participate in interviews, dedicating their time, or becoming involved in our project more directly.

Special thanks to Ro3kvit's partners: the Kharkiv School of Architecture and the Ukraine Rebuilding Action Group of the American Planning Association, that provided ideas and input during the process. And last but not least, the supporters of Greenpeace Central and Eastern Europe who made this project possible.

Special thanks to experts and representatives of local communities who contributed to this report with consultations: Oleksii Vasyluik, Tetiana Zhevzharova, Daria Korba, Nazarii Lisnyi, Danylo Orfin, Yurii Tereshenko.

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State agency of water resources of Ukraine

Kremenchuk City Council

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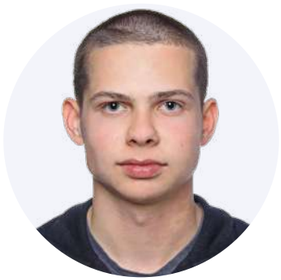
Fulco Treffers

“I have always been jealous of people living in cities with a large river. A river means so much to people. It gives identity, it cools, it helps orientating, it gives perspectives. For me, the shining water comforts. But I know, the water gives so much more than that. The power of water. The strength of the river. The vulnerability of the Dnipro River. The river is an economic base for industry, trade and fishery. And the river is of course the water itself. It is distracted from the river and is used for many different purposes, like households, agriculture and cooling of industrial activities and powerplants.

Two years ago I saw the Dnipro River water level rising due to attacks on the water management system. People and buildings got wet feet. Those were only small effects of the attacks. We decided to study the river, to look at all the potential. Not much later there was the brutal attack on the Kakhovka dam. Political statements about rebuilding were made. Expert opinions were given. And I knew we had every reason to continue this multi-layered work and to see the river in all its beauty and vulnerability. Since a few months, I have my own apartment in Kyiv from which I can almost see the Dnipro River. When I need some rest, I walk or cycle around the Trukhaniv island. To be with the water.”

Fulco Treffers is CEO and co-founder of Ro3kvit. He is lead urbanist of the urban and regional planning projects. Treffers (The Netherlands) works in Ukraine since 2015 as consultant and urban strategist for municipalities. He largely reduced his work in The Netherlands for his office called 12N Urban Matters to be able to work on the recovery of Ukraine. He was involved as tutor and developer at the Kharkiv School of Architecture. His specialisms are social urban design, participation and circularity.



Antoine Korchagin

“Growing up in Kyiv, I was always charmed by the beauty and impressed by the size of the Dnipro River. For me, the Dnipro was always an element of pride. It was the first thing I wanted to show everyone who visited my city, impatiently waiting to see their reaction as we drove across one of the bridges. As Hohol wrote, “There is no river like it in the world...” It is an inseparable element of my home city and my country and, thus, part and parcel of my identity. However, as much as I cannot unsee the value of the Dnipro River, I also cannot ignore the immense unused potential, the many challenges and points of vulnerability that have existed for decades but became so much more evident since russia’s full-scale invasion in 2022.

For me, this project was an opportunity to ‘get to know’ the river and the history of our human interaction with it, to analyse its role for Ukraine, and to address the challenges we are facing. While being highly attentive to the current realities of the war and accounting for the consequences and implications of russia’s terrorist military aggression, this project also allowed me to think of the ways to deliver a safer, more resilient, and more sustainable environment for Ukraine, where nature and humans both prosper. I hope my contributions to this project will be valuable for the ongoing and future efforts in making the Dnipro River and Ukraine a place that reflects those aspirations.”

Antoine Korchagin is a Franco-Ukrainian from Kyiv, currently based in London. Pursuing postgraduate studies in Regional and Urban Planning at the London School of Economics (LSE). Alumni of University College London (UCL) with a BA in History, Politics and Ecnomics. Antoine was engaged in various initiatives and organisations including the Ukrainian Institute London, NGO Renovation Map, the Ukrainian Embassy in the USA. He also founded and presided the Ukrainian Society at UCL, organising numerous events and projects aimed at promoting Ukrainian culture. He is a member of Ro3kvit since July 2023.

Svitlana Usychenko

“As a spatial researcher and designer, I have always been captivated by the interaction between humans and environmental systems. As I grew up in Kyiv, the Dnipro River was constantly present in my daily life. It was a visual inspiration, a mysterious power of nature and a huge obstacle to cross in the morning traffic jams. Just five minutes from our summer house, the Kaniv Reservoir is a peaceful place for swimming, playing, and walking along the endless dykes. These varied experiences along the same river sparked my curiosity. What impact do our design solutions have on the River? How do we interact with it? What interventions shape the River’s unique identity in each city?

Participating in the Dnipro River project allows me to explore diverse perspectives and develop scenarios for preserving this vital part of our environment, despite all the threats. Water in urban settings has been a prominent theme in my recent design activities, such as the revitalisation of Mykolaiv’s industrial riverfront and the strategy for Ochakiv’s waterfront. Being eternally interested in this dynamic topic I hope to continue researching and planning for the Dnipro River with other indifferent people.”

Svitlana Usychenko specialises in spatial research and strategies for circular and resilient built environments. She is a part of Ro3kvit Urban Coalition for Ukraine and NGO ReThink. With an MSc in Architecture and Urban Design from Politecnico di Milano, she has enriched her experience through diverse projects across Ukraine, advocating for green reconstruction and empowering local communities in urban development. Her approach integrates data analysis with participatory connections to people’s needs and the history of their spaces.

Vaagn Mnatsakanian

“For me, the Dnipro River is like an equator because since childhood, all our journeys from Mariupol to central or western Ukraine crossed the Dnipro, and it was always a significant event. Whether we traveled by car or by train, we would always press our faces against the windows, paying tribute to this mighty river and realising that half of our long journey was already behind us.

The Dnipro River is not just a water resource but the heart and soul of our country. It plays a key role in the economy, ecology, and culture of Ukraine. For centuries, the Dnipro has symbolised the connection between generations, supporting the life and development of many cities and villages. That is why this project holds special significance, and we want to draw the attention of the international community, the state, and businesses to actively participate in preserving the Dnipro.

This involves numerous challenges, including the need for significant investments, changing existing approaches to water resource management, and actively implementing innovative solutions. Our vision for the development of the Dnipro River is based on respect for nature and the pursuit of a sustainable future. I sincerely hope that this project will be an important step towards preserving and improving our river and call on all interested parties to join us in this noble cause.”

Vaagn Mnatsakanian is a certified energy manager, master of energy engineering, and holds a PhD in environmental safety. He has 15 years of experience in these fields in the city of Mariupol, which was the leader among the cities of Ukraine in terms of development. He has been working at the municipality of Arnhem (The Netherlands) since 2023.

Hristo Panchev

“I knew Dnipro and Danube as the two great rivers feeding my beloved Black Sea. So on my first trip to Kyiv, March 2024, my excitement was to see the river. Indeed, the Dnipro makes the city what it is. Vibrant, young, inspiring. A place you want to be. And not even the war can change that! Few days later in Kremenchuk I was awakened by a distinct rumbling sound and wailing sirens. A missile hit the ground 20 km from the city. I later learned that the Kremenchuk hydro power plant, one of the largest on the Dnipro cascade, was targeted. My mission was to explore the options for energy decentralisation through efficiency and renewable energy, and that coincided with the worst attacks on the country’s energy infrastructure. The situation in Ukraine was showing the entire world that it’s time for new energy solutions.

For me, green energy was the initial spark for this project. The success of our work at Greenpeace to rebuild the hospital in the village of Horenka encouraged us to scale up. Our goal was to show how an entire city or region could become energy independent and carbon neutral. We invited Ro3kvit to collaborate and focused on the river, because Dnipro is the link to everything. It is quality of life, culture and tradition. It is the intersection of many challenges, from the ongoing war to the global future of climate insecurity. Dnipro hides problems, but also millions of opportunities. And yes, Dnipro is energy. Because a sustainable city means healthy nature, clean water, rich biodiversity, prosperous society, safe and thriving Dnipro River.”

Hristo Panchev is part of Greenpeace Central and Eastern Europe as coordinator in the Green Reconstruction of Ukraine initiative. Based in Bulgaria, he leads the Eco City Model campaign, which includes the realisation of the Dnipro River Integrated Vision. Expert and communicator in the field of energy, climate change, and the role of human behavior in the transition to carbon neutrality. PhD in Communication Sciences and Semiotics.

Angel Bondov

“Water is life and life is water. It sounds like a cliche but it reflects reality. When we started discussing the green reconstruction of Ukraine, firstly we were thinking about the reconstruction of cities. After hours and hours of brain attacks we reach the idea to go big and brave and go for Dnipro river. What better way to showcase the way of green reconstruction than dealing with this magnificent river. Analysing the complexity, respecting the identity and making the first step for revitalisation of one of the symbols of Ukraine - the feeling can not be described by words!

When digging deeper and getting more and more familiar with the topic, one word pops up into my mind - grandeur. I realised that we are analysing not just a river, but a symbol of glory, greatness and life. It integrates and supports so many spheres of human life, as well as nature and biodiversity. I am really proud and thankful to have the opportunity to work on this project. I hope that me and the team will help people in Ukraine to rediscover and connect to the Dnipro river in their own magical way!”

Angel Bondov is an urbanist by education and vocation. He believes that the “ideal” way of planning cities should combine the flexibility, creativity and informality of bottom-up approaches with the systematic, holistic and formal ways of top-down urban planning. According to Angel, developing solutions to problems, related to cities, must involve the human perspective in all steps of the problem-solving process. Because of his beliefs for the last 10 years Angel had been team leading, participating and designing inclusive placemaking processes in 15 public spaces in Bulgaria as well as numerous strategic plans , GIS research and analysis. He is part of the professional network Placemaking Europe and co-founder of |In|Formal association. Currently, Angel is working for Greenpeace - Bulgaria as a community organiser and urban planner.

Tim Van Epp

“In the 1990s, I had the privilege of managing and supporting the $87 million USAID Environmental Policy & Technology Project for the New Independent States of the former Soviet Union. My duties included leading home office support to Ukraine and providing regular technical inputs and visits to the Kyiv regional office and Donetsk project office. In the Donbas region I provided training, capacity building, and demonstration projects on environmental management and waste management for the 65 most polluting industrial facilities in the region.

In 1997, I formed Eurasia Environmental Associates, LLC. In the ensuing 25 years I have completed many more environmental projects in Ukraine, as well as throughout the Eurasia transition economies region. These projects, which have included several river basin environmental initiatives, have been funded by the full range of international development aid agencies and donors. As a result of this work, I believed I should help preserve and extend the progress we have made in Ukraine and Eurasia and that I have the right experience and skills to contribute to this effort through the Dnipro River Plan.”

Tim Van Epp, FAICP, Managing Director of Eurasia Environmental Associates LLC, has over 45 years of experience providing environmental sustainability and climate action planning to clients in over 40 countries and 25 US states. Internationally, he has developed national, sub-national and local environmental sustainability strategies; environmental threats and opportunities assessments; environmental sustainability and green infrastructure plans; and biodiversity conservation plans in Ukraine, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Iran, Afghanistan, Mongolia, China, Zambia and US. He is a Past Chair of APA’s International Division, which won best overall performance by a division for 2 of the 4 years (2014-2018) he was Chair and won the Terry Holzheimer Leadership Award by the APA Divisions Council.

Niall Buckley

“I’ve been working in the field of energy, specifically complex urban and rural energy systems that integrate with local environments, for almost a decade. So, it was hard to say no when Fulco asked if I could support the project. Not only does the project promote a prosperous Ukraine, but it also epitomises the challenges and actions needed to support the global environmental issues we face today.

Moreover, river-based urban centers have always fascinated me with their complex systems and networks, often intertwined with their local fluvial systems that have developed over centuries or even millennia. From early settlements using the local river source for food, water, and transport to evolving the local economy via trade and sharing of technology as well as the historical and spiritual relevance to the local inhabitants, these river systems have played pivotal roles in the growth of our cities; however, with time, technology, and economic growth, these river systems have fallen into states of degradation which have had holistic negative impacts on their inhabitants as well local biodiversity’s.

As part of this project, I helped test future environmentally friendly and resilient energy scenarios in the Dnipro regen with amazing support from my revered colleagues. Moreover, these scenarios support the Dnipro area and can be used as archetypical energy scenarios for similar areas across the region.”

Niall Buckley is involved in R&D at IES, a climate tech firm. Before joining IES, he completed his PhD at University College Dublin (UCD) and was a visiting PhD Researcher at Massachusetts Institute of Technology (MIT). Niall specializes in developing technology that supports the holistic improvement of our existing and future built environments using digital twin technologies. Niall also runs energy master planning classes at UCD as an Adjunct Assistant Professor of Architecture.

Part 1
The Dnipro River Context

Contents

Summary

What is the Dnipro River? In this chapter we start from the basics by looking at the geographical and physical characteristics to identify the river in space: Where it begins? Where it flows? Where it ends? 2,285 km long, the Dnipro River is the fourth longest river in Europe and the longest in Ukraine. With its dense hydrographic network and numerous tributaries it is also the third largest by basin area, covering 509,000 km2, including parts of russia, Belarus and almost half of Ukraine's territory.

That said, we take a step back to look into the past, to see how humans have interacted with the river throughout the centuries and millennia. From the Skythians in the ancient times, to the Kyivian Rus in Middle Ages, the Cossacks in the Early Modern times, the times of the russian and soviet empires and into the modern days, the Dnipro River played a defining role for millions of people. But while its centrality remain unchallenged, its shape and size have been subject to significant changes. Our historical overview explores these transformations, highlighting the most important places and events associated with the Dnipro River. We look at cities, trade routes, fishing, navigation, but also the famous Dnipro Rapids, and at how these rapids were flooded together with thousands of hectares of land, due to the erection of the Dnipro Cascade of reservoirs throughout the 20th century. We explore some of the political, economic, social, cultural dimensions of those changes.

Gradually shifting the lens to the modern times, we look at the demographics around the Dnipro River. With dozens of cities and many more villages located along its banks, including the capital Kyiv, but also Dnipro, Zaporizhzhia, Kherson and others, the Dnipro River acts like a magnet, attracting people with its beauty, but also strategic benefits and functionality. We finish by considering how modern political borders, since the collapse of the Soviet Union in 1991 have shaped the development of the River and what the implications for Ukraine are. An international River, a transboundary river, it is also a source of tension and challenges, which we analyse with references to other examples.

1.1. Physical geography

1.1.1. General characteristics

The Dnipro River's full length is 2,285 km and its river basin covers 509,000 km2, making it the fourth largest river in Europe by length and third largest by basin area (DRBMP, 2023, p.15). It originates from the Aksyoninsky Mokh swamp on the southern slopes of the Valdai Hills (Smolensk Oblast, russian Federation), flows through the territory of Belarus and into Ukraine, crossing from north to south, eventually flowing into the Dniprovskyi Lyman of the Black Sea (Khilchevskiy, 2020). In Ukraine, the Dnipro River is by far the largest river, with a main channel 981 km long (125km shared on the border with Belarus) and a 292,700 km2 area basin, covering 48.8% of the country's total territory (DRBMP, 2023, p.15).

1.1.2. Hydrography

The Dnipro River is a typical lowland river. The hydrographic network of the Dnipro River basin is most densely developed in the upper part within the zone of mixed forests (0.39 km/km^2) and least densely developed within the steppe (up to 0.2 km/km^2). It includes 1,311 rivers with a drainage area exceeding 10 km^2, 320 reservoirs (with a volume exceeding 1 million m^3), and 16 lakes (with water surface area exceeding 0.5 km^2) (DRBMP, 2023, p.15). Among the main tributaries of the Dnipro River are on the right bank: Beresina, Prypiat, Teteriv, Ros, and Ingulets rivers; on the left bank: Sozh, Desna, Sula, Psel, Vorskla, Oril, and Samara rivers (Khilchevskiy, 2020). In its upper reaches (up to Dorogobuzh, Smolensk region, russia) the Dnipro River meanders through a narrow valley with a bed width of up to 30 m. Further downstream, the river bed widens to 40-125 m and the valley reaches 3-10 km in width. Near the city of Orsha (Vitebsk region, Belarus) the Dnipro River crosses a sandstone ridge. On its entry into Ukraine, the river's course is meandering, forming multiple branches, rapids, islands, and shoals. The width of the valley increases up to 18 km, with floodplains reaching up to 12 km (Khilchevskiy, 2020).

Downstream from Kyiv, the Dnipro River valley is asymmetrical: the right banks are steep and high, while the left banks are low and gently sloping. Along the Dnipro Upland, the course veers to the southeast. Between the cities of Dnipro and Zaporizhzhia, the river crosses the Ukrainian crystalline shield marked by outcrops of granite, gneiss, and other native rocks in the riverbed.

The famous Dnipro Rapids (see also chapter 1.2.) used to hinder navigation, however since the construction of dams and reservoirs they are mostly now underwater. After the city of Zaporizhzhia the river flows through the Dnipro Lowland forming numerous branches and channels, especially below the city of Kherson. Further downstream towards the river mouth, the floodplain of the Dnipro widens to 20 km, and the area of the delta reaches 350 km^2. Together with the Southern Buh river Estuary, the Dnipro Estuary forms the Dnipro-Buh Estuary of the Black Sea (Khilchevskiy, 2020).

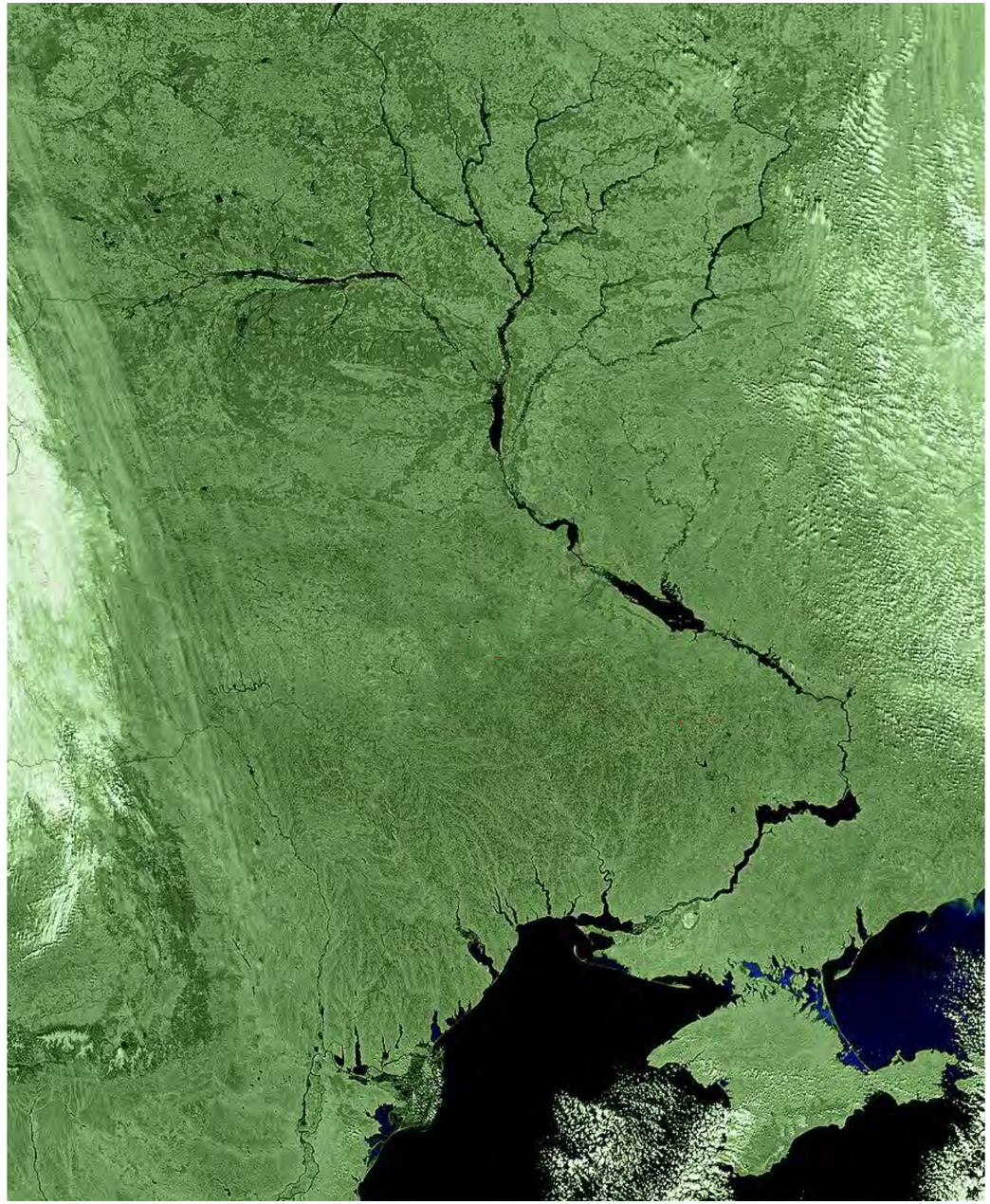


Figure 1. A satellite image of the Dnipro River and its tributaries, forming the trunk of this tree-like structure. The borders of three countries snake along the rivers, sometimes following their flow, but often not. Russia is in the top right corner of the image, Ukraine forms the lower third, and Belarus is in the upper left corner. Date: April 15, 2004.Source: NASA MODIS; Author: Jacques Descloitres; Accessed at: visibleearth.nasa.gov. (colors adjusted).

1.1.3. River basin partition

Historically, according to the physical-geographical conditions and factors influencing the river discharge, the Dnipro River was divided into three broad sections: the Upper Dnipro (upstream of Kyiv), Middle Dnipro (from Kyiv to Zaporizhzhia), and Lower Dnipro (from Zaporizhzhia to the estuary). This partition coincides somewhat with the borders of natural zones in the region, namely polissia, forest-steppe and steppe. With the creation of the cascade of reservoirs, the relevance of this division has somewhat decreased (Khilchevskiy, 2020).

However, the division persists and according to the order of the Ministry of Ecology and Natural Resources of Ukraine No.103 dated March 3, 2017, "On the Approval of the Boundaries of River Basin Districts, Sub-Basins, and Water Management Areas," the Dnipro River Basin is divided into 59 water management areas and 5 sub-basins" (DRBMP, 2023, p.15), including (see Figure 3):

1. The Upper Dnipro Sub-basin
2. The Middle Dnipro Sub-basin
3. The Lower Dnipro Sub-basin
4. The Prypiat River Sub-basin
5. The Desna River Sub-basin

1.1.4. Geology and hydrogeology

Located within the East-European Craton (also Sarmatian Craton), the river basin sits on a combination of land masses including the Ukrainian Shield (Crystalline Massif), Volyn-Podolian Plate, Dnipro-Donetsk Depression, the Southern Ukrainian Monocline, as well as the Folded-Cover Structure of the Donbas (DRBMP, 2023, p.15). Based on the different formations and features of this geological structure, we can differentiate five hydrogeological (groundwater) regions within the Dnipro basin (DRBMP, 2023, p.17):

1. *Volyno-Podilsky Artesian Basin*: multi-layered system of aquifers, with thick fresh water zone ranging from 70 to 1000m deep.
2. *Hydrogeological Region of the Ukrainian Shield* consisting of two structural levels: lower magmatic and metamorphic rocks and upper sedimentary deposits
3. *Dnipro-Donetsk Artesian Basin*: classic artesian basin with depths of the active water exchange zone ranging from 800 to 1000m.
4. *Donetsk Hydrogeological Folded Area:* mainly associated with Quaternary, Neogene, Paleogene, Cretaceous, Triassic, and Carboniferous deposits.
5. *Black Sea Artesian Basin*: active water exchange zone with a thickness of 50–400m, characterized by a wide development of brackish and saline waters.

Figure 2. Map of the Dnipro River largest tributaries
Authors: Elaborated by Ro3kvit and Greenpeace CEE

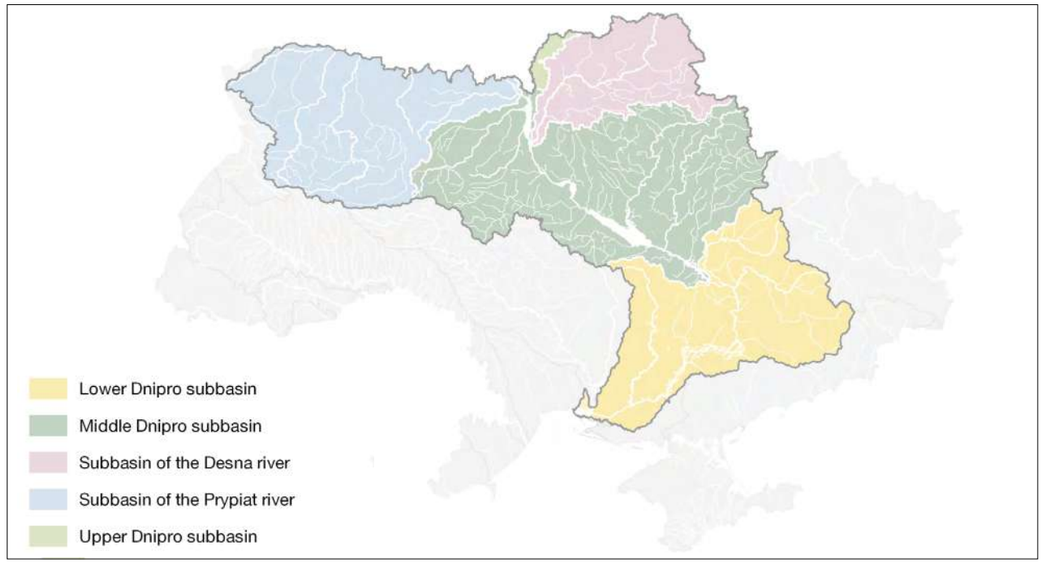


Figure 3. Map of the Dnipro River basin partition
Authors: Elaborated by Ro3kvit and Greenpeace CEE

1.1.5. Hydrology

The Dnipro River has mixed sources of water supply. In the upper part of its basin, snowmelt accounts for the majority (50%) of water supply, while rainfall and underground sources contribute 20% and 30% respectively. Further downstream, within the steppe zone, the proportion of snowmelt increases to 85-90%, while underground sources decrease to 10-15%, and rainfall becomes almost negligible (Khilchevskiy, 2020). The majority of the discharge of the entire river (over 80%) is generated upstream of Kyiv, with 32% on the territory of Russia, 31% in Belarus, and 37% in Ukraine. Over time, the volume of discharge has ranged from 22.6 to 96 km³ at it's mouth. Currently, at the river's mouth it stands on average at 53 km³, decreasing to 43.5 km³ in low-water years.

The average water flow increases from 593 m³/s at the Nedanchychi Hydrological Post (last measure of Dnipro's natural / unregulated flow) to 1,391 m³/s in Kyiv just below the Dnipro River's confluence with its tributary Desna, increasing to 1,672 m³/s in Dnipro city and finally reaching an average flow of 1,690 m³/s in the Dnipro Estuary (DRBMP, 2023). The largest tributary of the Dnipro within Ukraine is the Prypiat River. The average long-term discharge of the river at its estuary before flowing into the Kyiv Reservoir is 426 l/s·km², lower than the water discharge of the Upper Dnipro (593 m³/s).

Within Ukraine, the Prypiat River contributes to 60% of the total discharge, amounting to 13.4 km³. The second-largest tributary of the Dnipro River within Ukraine is the Desna River. The average long-term discharge of the river at its confluence with the Dnipro, is 350 m³/s. The average annual volume of its runoff is 11.0 km³, constituting one-fourth of the Dnipro River's discharge near Kyiv.

Among the distinct features of the Dnipro River's hydrological regime are spring floods marking the highest water flow, low water levels in summer (with periodic rain floods), irregular autumn floods, and low water levels in winter. In the Upper Dnipro ice formation begins in early December and ice break-up in early April, while in the Lower Dnipro this period is shorter: from late December to early March. Minimum water flow on the Dnipro River and its tributaries is observed at the end of summer and the beginning of autumn. In the middle and lower reaches of the river water flows are regulated by hydropower plants, generally maintaining a low daily flow corresponding to the minimum ecological requirement set by the regulations.

After the destruction of the Kakhovka Hydroelectric Station on June 6, 2023, the hydrological regime of the lower Dnipro underwent fundamental changes with water level fluctuations downstream now depending almost entirely on discharges from the DniproHES. In the Estuary and the lower reaches, there is also some influence of tidal phenomena. (DRBMP, 2023; Khilchevskiy, 2020)

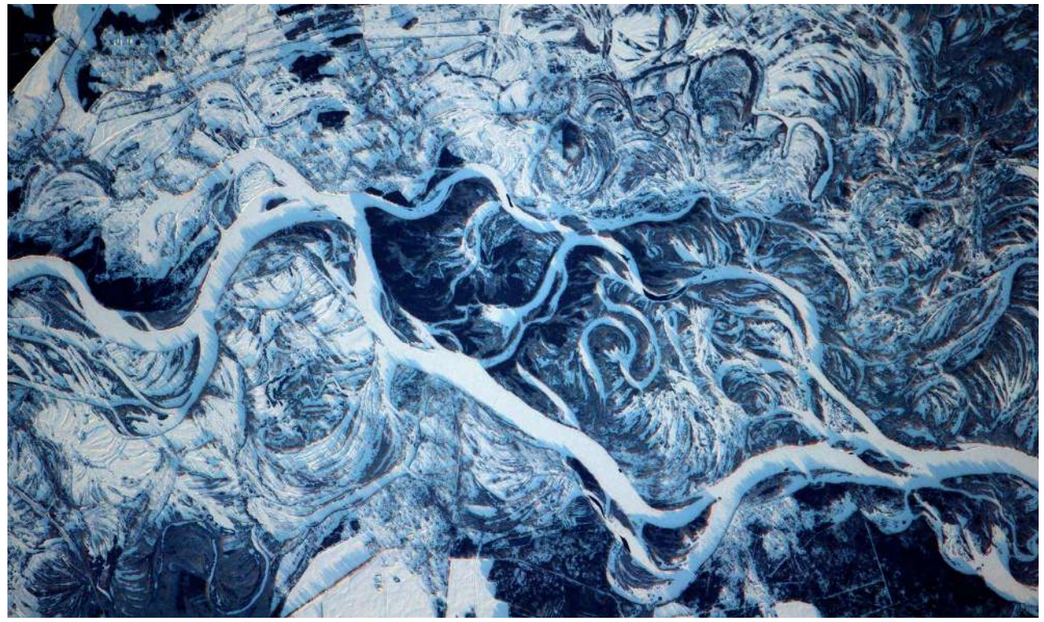


Figure 4. A photograph of the Dinpro River north of Kyiv covered in ice and snow, taken from the International Space Station in February 2017. Source: NASA / ESA/ Thomas Pesquet

Figure 5. A satellite image of the Dnipro River covered in ice during an unsually cold winter in March 2012. Source: NASA Earth Observatory (Public Domain)

1.1.6. Topography

The surface topography of the river basin reflects the geological structure, tectonic activity and external accumulative and erosive processes.

In the northwest of the basin lies the Polissia Lowland, marked by a predominantly flat terrain with elevations ranging from 150 m to 200 m, exceptionally rising to 300 m in the Ovruch ridge. To the west, the Volyn and Podolian Uplands are charactarised by the Kremenets Mountains and the Voronyaki exceeding 400 m. Towards the east, the Dnipro Upland (Prydniprovska vysochyna) ranges from 270 to 321 m.

In the Dnipro Lowland elevations decrease southwards from 170 m to 90 m. The Poltava Plain heights range from 176 to 202 m. To the north-east, the Dnipro Lowland transitions into the south-western slope of the Central Russian Upland, with elevations of 200-230 m, while to the south-east it borders the Pryazovian Upland, with the highest elevation reaching 324 m.

Finally, to the south of the basin, the Black Sea Lowland gradually decreases from 100-120 m to sea level down towards the coast (DRBMP, 2023, p.16).

1.1.7. Surface soils

The Dnipro river basin is situated within two soil zones of Europe, which correspond with bioclimatic zones.

First, the boreal zone (temperate cold) corresponds with the Polissia natural zone. Main soils types are sod-podzolic, sod, and sod carbonate. The river valleys within the boundaries of Polissia and the Western Forest-Steppe include peaty, bog, and alluvial soils, while on floodplains and overbank river terraces meadow-gley, meadow-bog, bog, and loamy-bog mineral soils are common (DRBMP, 2023, p.17).

Second, the sub-boreal zone (temperate) corresponds with the natural zones of Forest-Steppe, Steppe and Dry Steppe. The Forest-Steppe encompasses about 160 soil types with a wide genetic and agronomic range, including grey forest soils (light grey, gray and dark grey), typical chernozems, leached chernozems, meadow-chernozems.

The Steppe is commonly covered with ordinary chernozems to the north and southern chernozems to the south. In the Forest-Steppe and Steppe, a variety of halomorphic soils are also formed such as zonal solonchaks, hygromorphic solonchaks, and solonets soils (DRBMP, 2023, p.17).

1.1.8. Climate

Ukraine experiences distinct seasonal variations, with well-defined spring and autumn periods. In the mixed-forest zone, winters are moderately cold and snowy with occasional thaws, while summers are warm, humid, and often marked by prolonged rainfall. The forest-steppe zone also has moderately cold winters with more frequent thaws, and the summer months see lower precipitation but are prone to rainstorms. In contrast, the steppe region is characterised by short, cold winters with frequent thaws and minimal snow cover, and hot, dry summers. The climate of the Dnipro River basin is moderately continental. The Dnipro River basin is located within two climatic regions: North Atlantic-Continental and South Atlantic-Continental.

The average annual air temperatures in the Dnipro River basin on average fluctuate between 5.9-9.8°C. The coldest month is January (-3 to -8°C). The highest average monthly air temperature is observed in July (17.8-22.0°C). The maximum annual air temperature is 34-40°C. In recent decades, there were almost no cold winters. Annual amounts of precipitation within individual watersheds decrease in the latitudinal direction, from 600-650 mm in the northwestern parts of the Dnipro River basin to 440-480 mm in the southern ones. In recent decades (1991-2010), the amount of precipitation in the winter months has become less, compared to the norm. At the same time, it has increased in September and October (EUWI+, 2020)

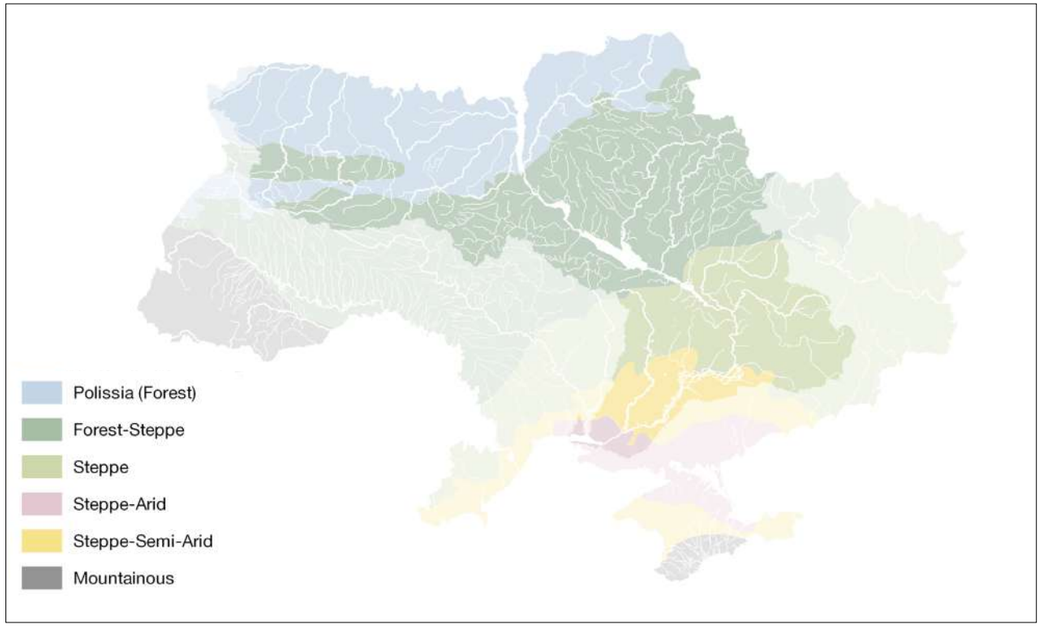


Figure 6. Map of natural climatic zones of Ukraine
Authors: Elaborated by Ro3kvit and Greenpeace CEE

1.2. Historical Overview

1.2.1. Origins: Prehistoric settlers on the banks of the Dnipro River

While the river's origins date back millions of years, deeply tied to the geological processes that shaped the landscape of the region, first anthropoid interaction with the river takes place in prehistoric times. Of course, direct historical records are scarce, but based on archelogical evidence we know that the Dnipro River and its surrounding basin witnessed movements of various ancient cultures and peoples, with the earliest evidence of human presence dating as far back as 40,000 years ago to the Paleolithic period.

Towards the Mesolith and Neolith there is evidence of more permanent settlements with communities engaged in agriculture and animal husbandry. Namely, the *Cucuteni–Trypillia* culture (c. 4800 to 3000 BC) has left a rich heritage of material artefacts discovered in various sites along the Dnipro River, most famously in Trypillia, south of Kyiv.

These, in turn, were consequently pushed out by consequent population movements of Iranic nomadic peoples from the East — first the Cimmerians (XV BC) and later the *Scythians* (VII—III BC). The latter were known for their skilled horsemanship and played a significant role in the cultural and economic landscape of the Pontic-Caspian steppe.

Scythian culture is rather well described not only through the material heritage left behind (statues, burial mounds with treasures, weapons, items of clothing), but also due to their ties and trade with the *Ancient Greeks* who established their colonies in Crimea and Ukraine's Black Sea shore in the VIII–V c. BC.

1.2.2. The Dnipro River in the Ancient times: First written mentions

It is during this period (450 years BC) that the first written mentions of the 'chief river of Scythia' are found in the works of the greek philosopher, historian and geographer Herodotus, who was visibly left amazed by the grandeur of the river, known at that time as the Borysthenes (greek. *Βορυσθένης*). Herodotus described it as "the most productive" river, and the biggest after the Nile: "Its course is from the north, and it is known as far as the Gerrhan land; that is, for forty days' voyage; beyond that, no one can say through what nations it flows; but it is plain that it flows through desolate country to the land of the farming Scythians" (Herodotus, The Histories, Book 4, Chapter 53).

In the centuries that followed, the lands of modern-day Ukraine already had a rather mixed ethnographic composition. Towards the III c. BC the Scythian lands are populated by *Sarmatians* (III–II c BC), who are gradually pushed out by the Migration of various Magyar and Fino-Ugric tribes including Goths and Huns, a period also known in western historiography as the 'Barbarian invasions'.

Towards the Middle Ages, the vast areas of the Steppe are occupied by Turkic nomadic groups from Central Asia — *Pechenegs and Cumans* — while the northern regions see the formation of Ancient protoslavic and slavic peoples.

Given these population moves, mentions about the Dnipro River can be found in various historical writings under different names: from hunnic *Var* to turkic *Özü*, and ultimately to various interpretations of Dnipro, as it is known today — from latin *Danapris*, *Niepr*, arabic *Dnabr* and old slavic *Днѣпръ*, to modern *Dnipr, Dniepr, Dnieper* and *Dnipro*.

While the origins of the names are debatable, the resemblance to Scythian *Dānu Apr* (deep river) and *Varu* (broad) or to Sarmatian *Dānu Apara* (farther river) suggest that the river's size and span had been noticed and admired by the earliest of our human ancestors.

1.2.3. From Varangians to the Greeks: The Kyivian Rus and the Middle Ages

Throughout the middle ages, the Dnipro River played a vital role in the political, economic and cultural life of the *Kyivian Rus* — the feodalist monarchical proto-state whose territories spread largely across the region of Eastern Europe, on lands that are today mostly divided between Ukraine, Belarus and Russia.

With its capital in Kyiv — one of the largest cities in Europe with a population exceeding 100,000 people at its golden age (X–XI c.) — the Kyivian Rus was one of the most powerful states on the continent. While its power and success were of course conditioned by a multitude of factors, the Dnipro River can confidently take some credit. Firstly, the Dnipro River played an immense role in navigation and trade, as the main waterway in the famous medieval trade route known as the *Way from the Varangians to the Greeks*, which connected the Baltics and Scandinavia in the North with the Black Sea in the South), and thus contributed significantly to the economic development of *Rus*. Besides its commercial significance, the Dnipro River occupied a central role in the kingdom's military successes, both through the strategic natural defence that its wide riverbed provided for the cities that were founded on its banks, but also for the multiple successful military campaigns that Kyivian rulers Olga, Svytoslav and Volodymyr led to Byzantium with boats sailing down the Dnipro River to Constantinople.

On the cultural front, the Dnipro River is also remembered through one of the keystone events in the history of the Kyivian Rus — the transition to Christianity during the reign of Volodymyr the Great. The Baptism of Rus and of its capital city Kyiv which occurred in 988 is described in various historical manuscripts, such as the *Kyivan Synopsis* (1674), which tell us that it is in the waters of the Dnipro River (more precisely at Dnipro's confluence with its tributary Pochayna River in Kyiv) that the people of *Rus* renounced paganism in favour of Christianisation. More importantly, the centrality of the Dnipro River at the time is evident from the several mentions surviving to our days in historical manuscripts, including, most famously the *Primary Chronicle*, as well as the epic poem *The Tale of Ihor's Campaign*, both written in old slavic and dated to the XII century, where the Dnipro River is sometimes poetically referred to as *Slavutych*, meaning the Slavic river, or, alternatively, the glorious river.

In the following decades and centuries, however, after the death of Yaroslav the Wise, the glorious river will witness what is known in the history of Ukraine as the dark age, a period marked by feuds, succession issues, fragmentation, wars and eventually the decline and disintegration of the once powerful medieval state, culminating in the Mongol siege and sack of Kyiv in 1240. This was followed by a century of Mongol domination and supremacy in the form of tribute, or in other cases vassalage of the Golden Horde until well into the XIV century.

Figure 1. Portolan Atlas (circa 1550, Italy). The Dnipro River and its tributaries can be seen at the center of the image.
Author: Battista Agnese; Accessed at: Wikipedia.org (Public Domain).

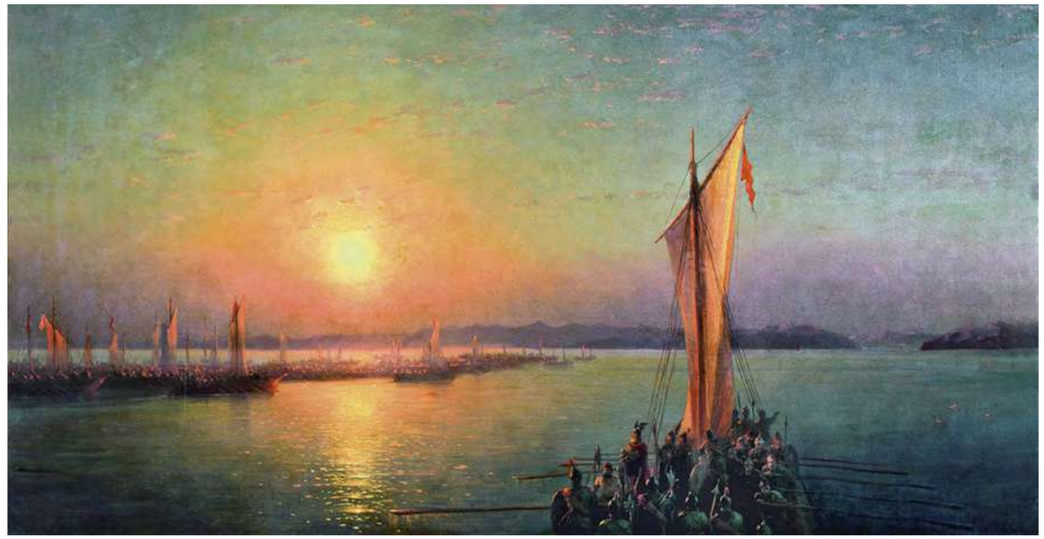


Figure 2. "Varangian saga – the path from the Varangians to the Greeks" (1876).
Author: Ivan Ayvazovsky. Accessed at: Wikipedia.org (Public Domain)

1.2.4. The Early Modern times: The river of the Cossacks

With the Early Modern period the Dnipro River comes again into the spotlight, as the development of cartography allows us to see. At times, its recognisable shape helps to locate the centre of what now emerges on the map as "*Ukraina*". In other instances, the usual thick line no longer serves merely to mark the river, but also major frontiers, demarcating key dividing lines between states, kingdoms and empires, shaping and defining political, social and cultural identities for centuries to come.

While the Dnipro River has always played a vital role for the societies and civilisations that have developed along and around it, few could probably claim to be closer to the Dnipro and its wild nature than the Cossacks. Known for their military prowess and freedom-loving lifestyle, the Cossacks were a semi-nomadic people who earned their livelihood through war and crafts.

As Mykhailo Hrushevskyi wrote, the first official mention of the Cossacks appeared in 1492, when warriors attacked a Turkish galley near Tiahyn Castle (modern Kherson region) and freed the Ukrainians who had been sold into slavery (Hrushevskiy, 1898). Based in the *Wild Field [Dyke Pole]* of the Steppe — a buffer zone between the Grand Duchy of Lithuania and its enemies the Tatars — the Cossacks were a group of diverse cultural and ethnic background, attracting both boyars, military people and professional soldiers deprived of their noble status, but also simple peasants or merchants in search of a better life, free of religious prejudice or enslavement.

References about the Dnipro River can be found in various written historical sources but also the literature of the time of the Cossack Hetmanate, including in the *Poems for the Mournful Funeral of the Honourable Knight Petro Konashevych Sahaidachnyi* of Kasian Sakovych, written in 1622, in the Cossack Chronicles of the XVI-XVIII centuries or, for instance, in *The Description of Ukraine* (1660) by the French engineer and the most famous cartographer of the 17th century, Guillaume Le Vasseur de Beauplan. Aside from his *Description*, received with great interest around Europe, where it was translated throughout the XVIII and XIX centuries, Le Vasseur was also the first to produce and publish several general and specialised maps of Ukraine, including of the Lower Dnipro and the Dnipro Rapids (IEU, 2009)

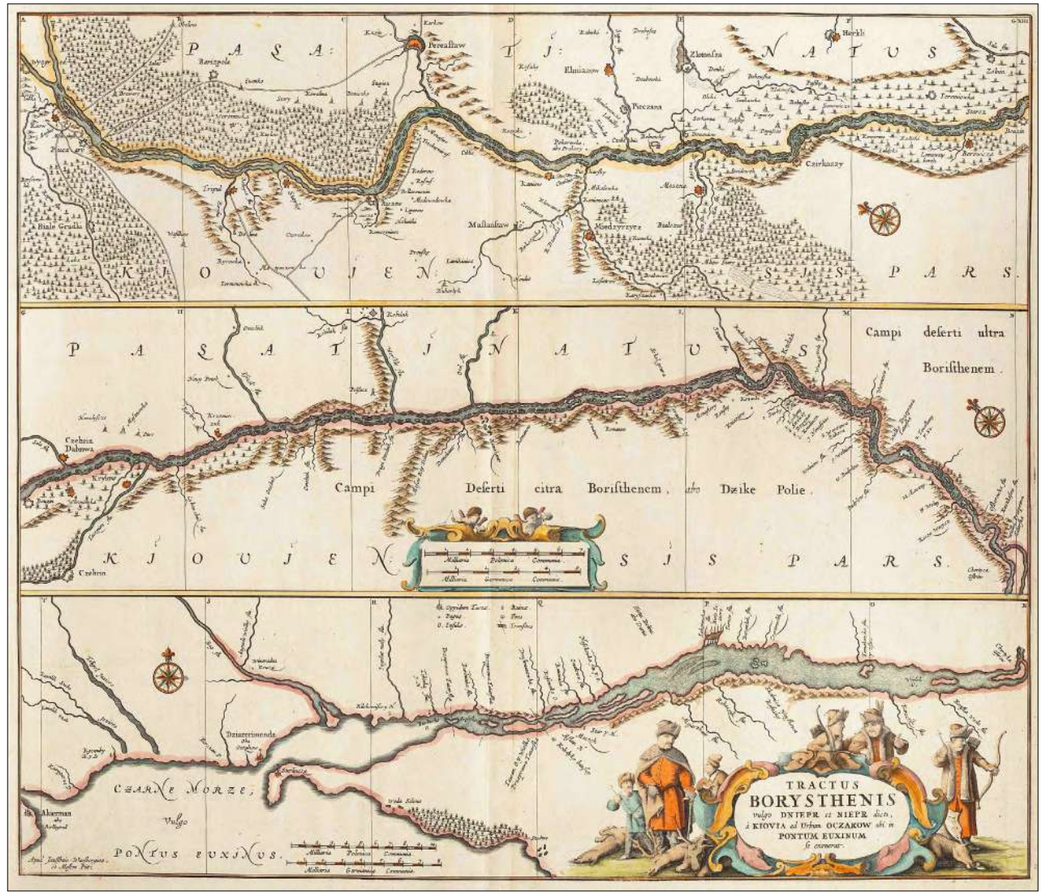


Figure 3. *Tractus Borysthenis vulgo Dniepr et Niepr Dicti, à Kiovia ufque ad Bouzin.* A 1680 re-edition by Jan Jansson of a series of three maps depicting the Dnipro River, originally produced by the famous french cartographer Guillaume Le Vasseur de Beauplan in 1662. The maps stand out for their high artistic level, detail, bright cartouches as well as detailed toponymy (names of cities and villages, the Dnipro Rapids, major churches and other special markings). Source: Moses Pitt; Accessed at: Wikipedia.org (CC BY-SA 3.0). Also see https://vkraina.com.ua.

Indeed, the connection of Cossacks to the Dnipro River is deeply rooted in their historical settlements along its banks, centred around the *Sich*. Beyond the reach of Warsaw, Istanbul, or Moscow's authority, or else the cavalry of the Crimean Khan, the *Velykiy Luh [The Grand Meadow]* became the flourishing ground for the Cossack community with its open-field democracy, military organization, commitment to justice, and love for freedom (Texty, 2023). The Sich repeatedly changed its location, but it always remained within the banks of the Dnipro River whose swamps and shallows protected it from the Tatars and Turkish galleys. From the mid-XVI and until the late XVIII centuries, due to various reasons, the Sich changed eight locations:

Khortytska Sich	1556—1557
Tomakivska Sich	1570s–1593
Bezavlutska Sich	1593–1630
Mykytynska Sich	1639–1652
Chortomlynska Sich	1652–1709
Kamianska Sich	1709–1711
Oleshkivska Sich	1711—1728
New or Pidpilnetska Sich	1734–1775

These locations in the middle of the *Great Meadow* were not accidental, as the Dnipro River has played a central role in the lifestyle and identity of the Cossacks. More than merely a waterway for navigation, trade or military campaigns, the Dnipro River both protected the Cossacks from enemies and offered them ample quantities of food. The Dnipro River and its channels were filled with various fish, while the meadows served as a feeding ground for the cattle. According to the Ukrainian historian and ethnographer Dmytro Yavornytsky, the fish from the Dnipro fed, clothed, shod, and armed the Cossacks (DARG, 2020). It is not puzzling, thus, why the Cossacks affectionately called the Dnipro 'their brother' and why sailors (*lotzmans*) referred to it as the 'Cossack path' (Texty, 2023). At the same time, the meadows, floodplains, channels, streams and lakes — including the famous *Great Meadow* [*Velykiy Luh*] — formed a ready-made natural fortress and an ideal shelter. Steppe Tatars always avoided the almost impassable *Great Meadow*, which was unsuitable for their cavalry. While serving as a natural barrier that provided the Cossacks with a strategic defensible position against various adversaries, the Dnipro River also facilitated their navigation, mobility and communication. It was along the Dnipro River that the Cossacks carried out their legendary campaigns against the Turks, among others.

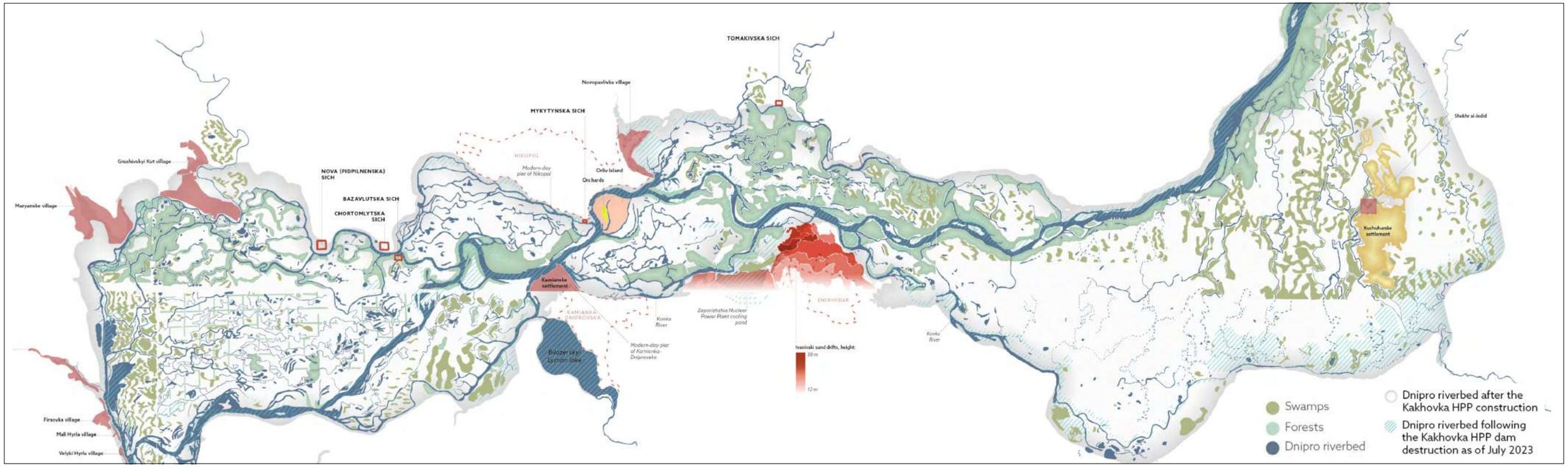


Figure 4. An excerpt from a map created by Texty.org.ua: "*Velykyi Luh: Map of the Great Meadow, Land of Ukrainian Cossack State, the Mongol Khan's headquarters and more*". Source: Texty.org.ua (check their website for an interactive version and description). The map shows the territories of the Grand Meadow and the Dnipro River before the construction of the Kakhovka HES in 1956. You can find some of the Cossack sich labeled, as well as other historical and natural sites.

Dnipro Unites

Throughout the XVI–XVIII centuries, the Cossacks had quickly been able to gain their seat at the table, participating in major military campaigns, forging alliances and treaties with or against the neighbouring Polish-Lithuanian Commonwealth, the russian Empire, the Ottoman Empire and the Crimean Khanate. Through their defining role on the ground, under the rule of their most renowned leader, Bohdan Khmelnytsky, the Cossacks won themselves the right to self-government and an independent Cossack state officially called the Cossack Hetmanate (1649–1764), also known as Hetmanshchyna the Cossack Republic, the Army of Zaporozhia, or simply “Ukraina”. This Ukraina emerged on many European maps, bringing the territories on both sides of the Dnipro River into one united body, symbolically marking the lands that would later come to constitute what today is known as Ukraine. For instance, the famous maps of Le Vasseur de Beauplan or Giacomo Cantelli reveal a “Ukraina”, alternatively called “the land of the Zaporozhian Cossacks”, crossed yet not divided by the thick line that defines the mighty Dnipro River.

Figure 5. Excerpt from the map “*Regni Polonia magni ducatus Lithuania*” of the Polish Lithuanian Commonwealth (1670); Author: Carlo Allard. Territories on both banks of the Dnipro Rier are seen to be refered as “Ukraina or the land of the Cossacks”, suggesting that both banks of the Dnipro River were accociated with and inhabited by this dominant group. On other maps of the same period the name “Zaporozhzhian Cossacks” can also be found. Accessed at: Wikipedia.org (Public Domain).

Dnipro Divides

At the same time, the natural thickness and span of the Dnipro River also made it a suitable natural borderline. Understandably, the Dnipro River served as the geographical line of division, sometimes between distinct peoples and sometimes between those who shared a similar or even the same language, culture, religion and ethnicity. The lower reaches of the Dnipro River remained a usual marker of division between the Orthodox/Christian/Slavic world and the Muslim/Turkish/tatar world. Most notably, however, the seventeenth century came to signify the Dnipro River as the demarcating line between the “right bank Ukraine” and the “left bank Ukraine”. This division emerged during the so-called political “Ruin” (Ruyina) in the second half of the seventeenth century after the death of Bohdan Khmelnytsky — a period of diminishing Cossack power in the face of internal and external pressures, culminating in the 1667 Truce of Andrusovo signed between the Tsardom of Russia and the Polish-Lithuanian Commonwealth, setting the borders over the territories of modern-day Ukraine and Belarus along the Dnipro river (Radio Svoboda). The Dnipro River remained a border between the Muscovite and Polish spheres of interest until the Second Partition of Poland in 1793 when Ukrainian territories on the right bank of the Dnipro were ceded to the russian empire.

Figure 6. Excerpt from the map “*Theatre de la Guerre Dans La Petite Tartarie La Crimee La Mer Noire*” (Amsterdam, 1740-45); Authors: Jean Covens & Corneille. While territories on both banks of the Dnipro River are still described as “*Ukraine or the country of the Cossacks*”, we now also see references and marking presenting wehre the Dnipro River corresponds to the “frontier” of the Crown lands of Russia, Poland, but also Tartaria. Source: Wikipedia.org (CC BY-SA 3.0); Accessed at: https://vkraina.com.ua

1.2.4. Industrialisation and the first steamboats on the Dnipro River

From the late 18th century and up until the Bolshevik Revolution of 1918, the Dnipro River remained from its origin in the Valdai hills and down to the Black Sea uninterrupted by borders, finding itself in its entirety within the Russian Empire. Without going into the complex political context, which, of course, is important too, it is during this time that we can observe the first significant technological advancements that fundamentally defined the way people interacted with the river. Progress in machinery and technological advancement spurred by the Industrial Revolution pushed for the development of rail transportation on land and new solutions for fluvial and maritime transportation. The first steamboat on the Dnipro River, known under the name of “Pchyolka” (“Little Bee”), was built in 1823 on the estate of Count Mikhail Vorontsov in Moshna (now Cherkasy Oblast).

This marked the beginning of steam navigation on the Dnipro, which took on a more organised character in 1835 when the first steamship company on the river was established (Korrespondent, 2015). The transport significance of the Dnipro River kept increasing throughout the XIX century. In 1858, when the *Dnipro Shipping Society [Суспільство пароплавства по Дніпру і його притоках]* was formed, navigation on the river began to flourish as regular steamship navigation started along the entire course of the Dnipro River. Passenger navigation gradually took on, transporting up to 2 million passengers per year during the peak period (Korrespondent.net, 2015). Steamship operated between Kherson and Mykolaiv, as well as along the Upper Dnipro and its tributaries Desna and Prypiat. At the beginning of the 20th century, the number of self-propelled vessels in the Dnipro River Basin amounted to 382, while the quantity of non-self-propelled vessels reached 2,226 (Ukrrichflot). The acceleration of river navigation came at a time of quick industrial growth and the growth of new and old urban centres across the empire. For instance, by the mid-XIX century, docks on the Podil riverside in Kyiv stretched to practically 1800 meters. At the end of the century, the Kyiv River port was expanded. Between 1848 and 1853, the first stationary bridge — the Nicholas Chain Bridge — was constructed across the Dnipro River in Kyiv, which was, at the time, the largest bridge in Europe, spanning 16 meters in width and 776 meters long. In the Lower Dnipro, the city of Kherson quickly developed as a centre of trade. In 1806, a shipbuilding factory was founded there, which produced from 20 to 30 ships per year. From 1833 and 1843, 187 vessels were built there. Overall, the nineteenth century sees the quick expansion of cities like Dnipro (Katerynoslav), Odesa, Zaporizhzhia, and Mykolaiv. At the same time, the expansion of the water network also occurred throughout the XVIII and XIX centuries in the Upper parts of the Dnipro River Basin to facilitate trade by connecting the Dnipro with other river systems through a series of canals. For instance, from 1765 to 1768, the Dnipro was connected with the basin of Niman through the Oginski Canal, and in 1775, the Royal Canal connected the Dnipro to the Visla – both private initiatives aimed at transporting forest wood from Polissia to the Baltic ports of Gdansk and Klaipeda. However, Initiatives aimed at the construction of bypass canals, dams, and locks to facilitate river traffic and make transportation more efficient were both challenging and costly.

Figure 7. Photo of the Dnipro riverside in Kyiv, 1900s
Source: unknown; Accessed at: Texty.org.ua (Public Domain)

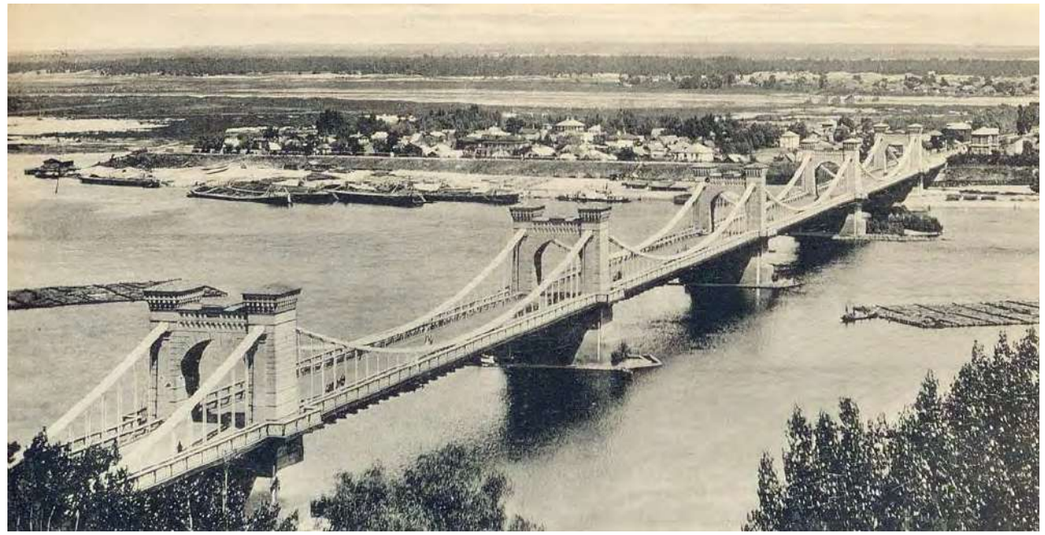


Figure 8. Photo of Nicholas Chain Bridge in Kyiv, 1898. Barges are seen on the background.
Source: unknown; Accessed at Wikipedia.org (Public Domain)

The Dnipro Rapids

One obstacle remained particularly hard to solve — the Dnipro Rapids. For almost 100 km between the modern-day cities of Dnipro and Zaporizhzhia, the Dnipro River transformed into a continuous set of obstacles, with water roaring through accumulations of granite boulders. Large stones and rocks that crossed part of the flow were called 'barriers'. Those that spanned the entire river were called 'rapids' [*пороги*].

But, while offering "a grandiose spectacle of living nature", the rapids posed the greatest of obstacles to those who navigated the river. For centuries, people have had to struggle against the river for the right to navigate it by boat, barge, or steamship. Not only ship captains feared them: among the locals, there was a belief that a demon sat at each rapid. This part of the river, marked by a 30-40m drop in height, contained 60 islands, 30 to 60 barriers and 9 rapids:

- Kodatsky [Кодацький]
- Sursky [Сурський]
- Lokhansky [Лоцманський]
- Dzvonetsky [Дзвонецький]
- Nenasytetsky [Ненаситецький]
- Vovnyzky [Вознизький]
- Budylskiy [Будильський]
- Lyshniy [Лишній]
- Vilnyi [Вільний]

The most dangerous was considered the Nenasytetsky rapid, also known as Nenasytets (–Insatiable), Revuchiy (–Roaring), Did (–Old man) or Rozbiynyk (–Bandit), which greedily claimed boat crews and barges that passed through it.

Whilst serving as an artillery captain for the army of the Kingdom of Poland, the famous French cartographer Guillaume Le Vasseur de Beauplan described his journey down the Dnipro River (1637-1638): "I have seen and crossed all Rapids, I have traversed all waterfalls against the current in a simple boat; at first glance, this seems impossible, because some thresholds have a drop of 7 to 8 steps — judge for yourself how skilful one must be with an oar".

Similarly, Segur left a vivid description of the rapid in his notes: "The Dnipro River in this place is cluttered with a chain of rocks, some of which are level with the water, while others rise above its level and, in places, form several such noisy waterfalls that we could not hear each other's words. The current here beats against the rocks with rage and foam. At first glance, it seems impossible to pass between these rocks even in the lightest boat and with the most courageous rowers" (Korrespondent, 2015).

Perhaps the most detailed account of the Dnipro Rapids was produced by the Ukrainian historian and ethnographer Dmytro Yavornytsy, who headed the Dniprobud expedition composed of the country's most prominent archaeologists in the early 1930s. The rocky Dnipro Rapids were described by Yavornytsky in his book "Dniprovi Porohy" and were also partially documented by the chroniclers of the All-Ukrainian Photo Cinema Administration (VUFKU) and photographer Maksym Zaliznyak (Dovzhenko Centre, 2023).

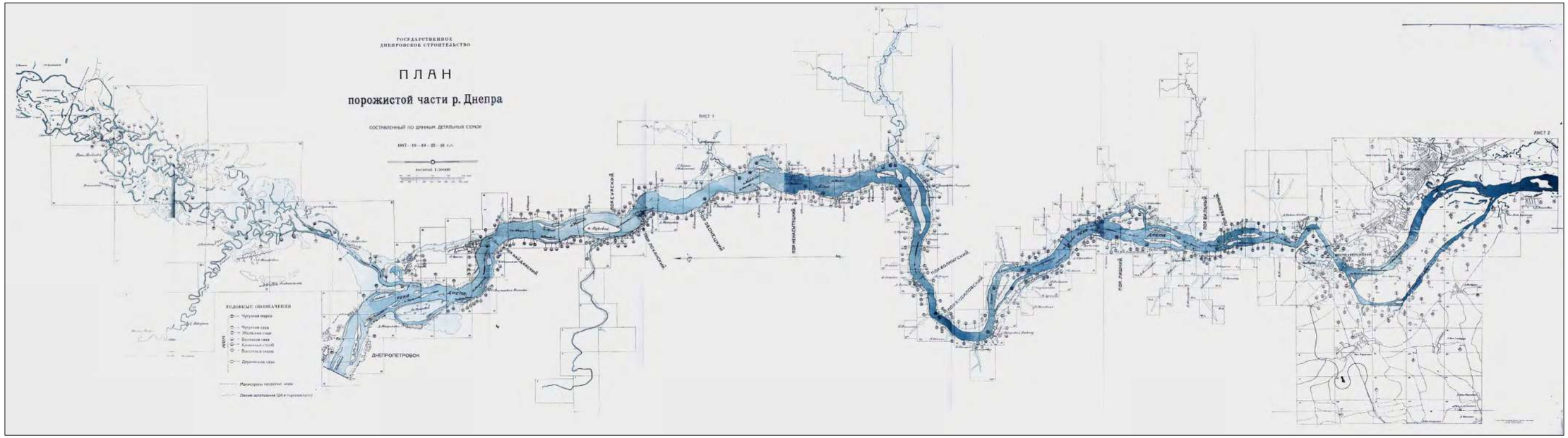


Figure 9. Map/plan of the Dnipro Rapids (1917–1921), Scale 1:50000
Source: State Dnipro Building Company *Dniprobud*. Accessed at: divingriver.com.ua

Overcoming the Dnipro Rapids

Attempts at clearing the fairway or even creating an artificial one have been made repeatedly since the 18th century. Among the first major efforts towards the enhancement of the navigability of the Dnipro River was the construction of a navigable canal carried out in 1789 by the russian landowner and colonel Mikhail Faleev under Prince Potemkin, known for his love of grandiose projects. However, solving the navigation problem proved elusive: the rapids still posed a danger to vessels passing through them (Korrespondent.net, 2015). In 1803-1805, a two-chamber lock with a weir of 4.27 meters was installed at the largest and most dangerous Nenasytets rapid. However, its design proved to be imperfect, and the lock was destroyed.

Under the project of Shchitov (16 locks on bypass canals along the rapids), work was carried out in 1833 and 1843-1853. They allowed the navigable navigation on the river to be extended by 1.5-2 months, and in some years - even for the whole summer. Projects to tame the rapids were being developed throughout the nineteenth century in 1878, 1880-1884, 1891, and later; however, with the development of railways, work on the Dnipro River took a back seat, and fluvial transport remained lacking behind the expanding railways. In 1905, the idea of using the river's energy emerged in the project of damming the rapids, which was proposed by engineers Maximov and Grafitio. However, the projects were not implemented due to the beginning of the First World War.

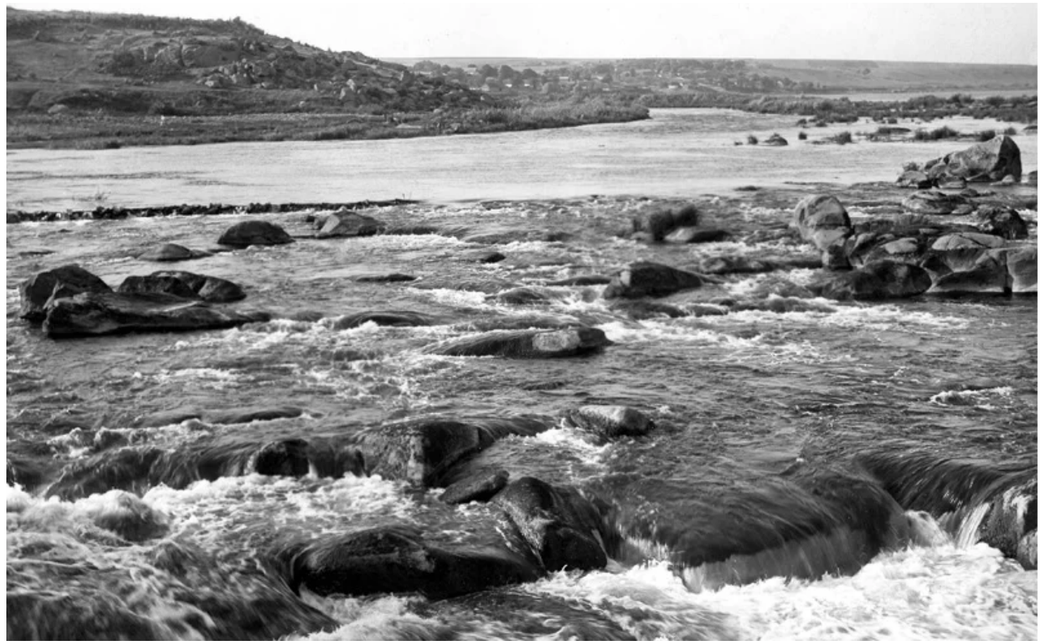


Figure 10. Photo of the Dnipro Rapids, more specifically the Nenasytenest Rapid, late 1920s.
Author: unknown. Source: Запорізький обласний краєзнавчий музей

Lotzmans and fishermen

Throughout the XVIII, XIX and early XX centuries, the navigation across the Dnipro Rapids relied on no other than the `Lotzmans`. Their job was safely delivering boats from before the first rapid Kodatsky to after the last Rapid with the symbolic name Vilny ('Free'). Lotzmans helped ferry people and cargo across the impassable rapids of the Dnipro River up until the early 1930s. They knew the Dnipro Rapids better than anyone else. They knew every stone here, so they could skillfully navigate all obstacles. Unsurprisingly, as they are commonly considered to be the descendants of the Zaporizhzhian Cossacks (Local History, 2023), their community formed after the destruction of the New Sich.

The Lotzmans were not the only ones able to match the connection of the Cossacks to the Dnipro River. At the same time, downstream of the rapids, in and around the Grand Meadow, fishermen continued to hold on to old Cossack traditions through attire, customs, and, of course, fishing. The locals often mentioned the Cossacks for almost any reason in their daily lives. The collective memory held historical names and toponyms", but the fishermen demonstrated their connection to Zaporizhzhia more than anyone else (Local History, 2023).

Figure 11. Members of the Dnipro archeological expedition next to the Vovnyzky Rapid (1931). On the background lotzmans on a barge. Author: Mark Zalizniak; Source: the Funds of the National Reserve "*Khortytsia*"

1.1.5. The Soviet electrification plan

The solution to the challenge of the Dnipro Rapids came during the Soviet period. Following the First World War (1914-1918) and the russian Civil War, marked by a short-lived Ukrainian independence from 1917 to 1921, the territory of Ukraine was to be occupied again. Bolshevik rule succeeded the centuries of imperial tsarist rule. In the first decade of their rule, however, the Soviet leadership faced inefficiencies of brutal “war communism” and therefore focused on economic development and modernisation as the strategy that would keep it afloat and maintain its political power. The electrification of the country was advertised as the solution to go forward. The Party commissioned the so-called “GOELRO” Plan, which consisted of the construction of large-scale energy infrastructure throughout the whole of the USSR that would make quick industrialisation and modernisation possible. What did the Dnipro River have to do with all of this? The electrification of Ukraine had been considered as “a top-priority task of exceptional state significance”. Thermal power stations in the Donbas were to be supplemented by a series of hydroelectric power stations along the Dnipro River to provide energy for the growing appetite of the Soviet military-industrial apparatus, delivering altogether a total capacity of 1 million kW. Quickly, the Dnipro River became the main actor — and in that regard, the victim — of the promised “bright Socialist future” (Babel, 2021).

Figure 11. Photo of the DnieproHES under construction, 1934
Author: unknown; Source: Wikipedia.org (Public Domain)

‘The Dniprelstan is built’

The first and the largest of the projects erected along the river was the Dnipro Hydroelectric Power Station (also known as DniproHES) in the city of Zaporizhzhia. The project designed by the scientist and hydrotechnician Ivan Alexandrov was approved as early as 1921 and launched in 1926. By the time of its construction (1927-1932) and until 1939, the DniproHES remained the largest power station in Europe and the third largest in the world by capacity (EMU, 2006). It increased the hydro-energy reserves of the Ukrainian SSR by 558,000 kW, with an initial production of merely 46,700 kW in 1923. At the same time, the total capacity of all power stations in Ukraine by 1935 has increased sevenfold, with as much as 4 billion kWh generated per year (Babel, 2021).

What the DniproHES also did, importantly, was providing a solution to the challenge that had troubled many merchants, navigators and engineers for centuries: the Dnipro Rapids. The rising water level meant that the numerous rocky rapids along the riverbed that obstructed navigation were submerged underwater, allowing for the creation of a continuous Dnipro River waterway from Kyiv to Kherson. Along the riverbanks, large ports emerged in Kyiv, Dnipropetrovsk (now Dnipro), Kherson, and the largest and most modern Zaporizhzhia River Port (Ukrrichflot). The uninterrupted water route also connected River ports with the maritime ports of the Black Sea. The volume of cargo transportation sharply increased, and new cargo ports emerged (Korrespondent, 2015).

Figure 12. Photograph of the general view on the DniproHES (1941)
Source: author unknonw, image provided by the State Archival Service of Ukraine, archives.gov.ua

A cascade of dams and reservoirs

During the Second World War, the DniproHES suffered two destructions. As the Germans invaded in 1941, Stalin ordered the destruction of the great Soviet dam in Zaporizhzhia, flooding a vast area and killing thousands. During Nazi occupation, the dam was rebuilt and partially put in operation. However, as the Soviet counteroffensive approached in 1943, the Germans blew up the dam again, trying to slow the advance of the Red Army (NYTimes, 2023; RadioLiberty, 2013).

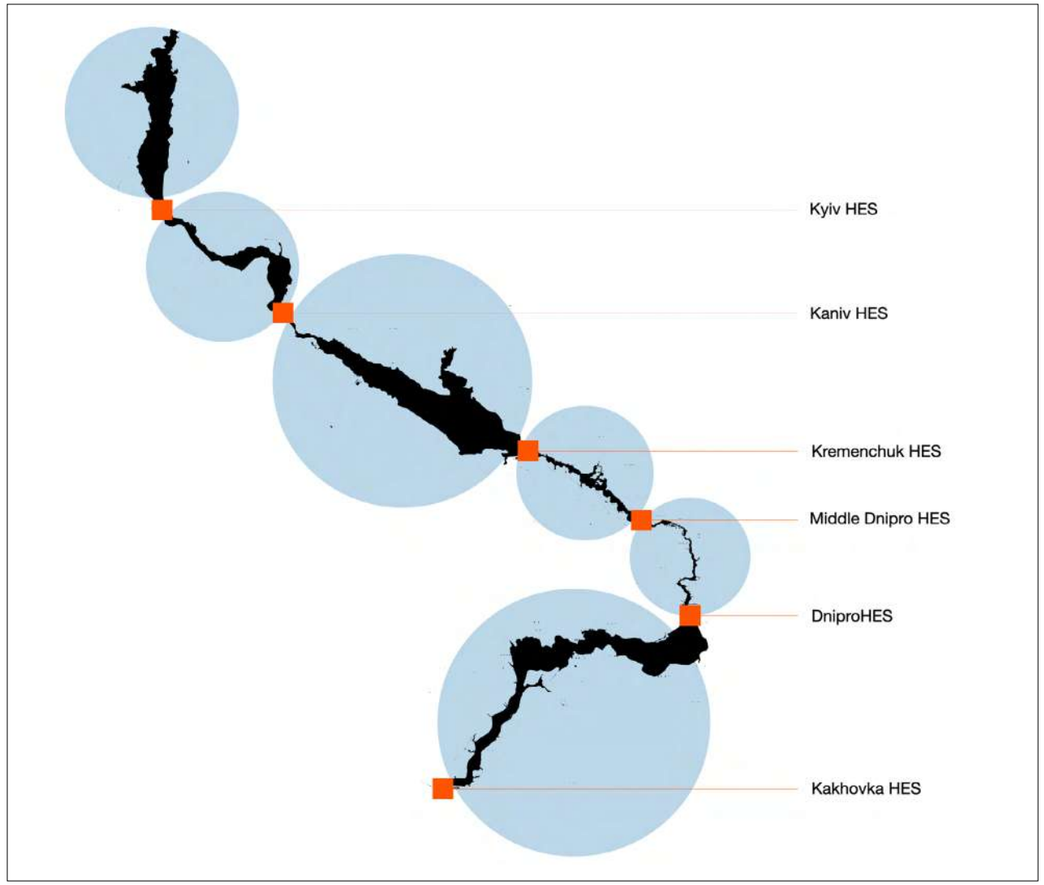
In the decades following the Second World War, the network of hydroelectric power stations was not only rebuilt but significantly expanded, with the reconstruction of the DniproHES (1944–1950) and the erection of another five dams within Ukraine from the mouth of Prypiat River on the border with Belarus in the North and to the city of Kakhovka in the south. In chronological order, the Kakhovka HES (1950) was erected, followed by the Kremenchuk HES (1959–60), the Middle Dnipro HES (1963), the Kyiv HES (1964–68) and ultimately the Kaniv HES (1972–75). The creation of a regulated water flow also allowed for the construction of the DniproHES-2 from 1969 to 1980, doubling the energy capacity produced at DniproHES. For the operation of the hydroelectric power stations, the Dnipro was effectively transformed into a cascade of reservoirs with a total surface area of 6,950 km² and a total volume of water of 43.8 km³. This constitutes 94.7% and 90.8%, respectively, of the total quantity of all major reservoirs in Ukraine. By the volume of water, the reservoirs of the Dnipro cascade can be classified as very large (Kremenchuk and Kakhovka reservoirs) and large (Kyiv, Kaniv, Kamianske, and Dnipro reservoirs).

The cascade of reservoirs accumulates 43.71 km³ of water (that is 82% of the Dnipro's annual discharge) (Khilchevskiy, 2020). As a consequence, out of the total length of the Dnipro River, which flows through the territory of Ukraine (981 km), only 100 km have been preserved in its natural state, while the rest is regulated by the cascade of Dnipro reservoirs for the operation of the hydroelectric power plants.

The cascade of hydroelectric power stations and reservoirs has solved the problem of uninterrupted provision of electricity and water for the population, industry, and agriculture. It has increased water consumption volumes and provided a more even distribution throughout the year. Additionally, it ensures the operation of hydroelectric, thermal, and nuclear power stations and water transport and protects the river valley from catastrophic floods. These successes had undoubtedly been instrumentalised by the Soviet propaganda machine to illustrate the "advantages of Socialism" and thus played an immense significance in helping the Bolshevik regime to maintain its grip on power (Babel, 2021).

Kyiv HES	Vyshhorod	1964–1968
Kaniv HES	Kaniv	1972–1975
Kremenchuk HES	Kremenchuk	1969–1960
Middle Dnipro HES	Kamianske	1963
DniproHES	Zaporizhzhia	1927–32, 1944–50
Kakhovka HES	Nova Kakhovka	1950

Figure 13. Scheme/Chart of the Dnipro Cascade
Author: Elaborated by Ro3kvit and Greenpeace CEE



Kyiv Reservoir	922 km²	3,730 m³
Kaniv Reservoir	675 km²	2,500 m³
Kremenchuk Reservoir	2,250 km²	13,250 m³
Kamianske Reservoir	567 km²	2,460 m³
Dnipro Reservoir	410 km²	3,320 m³
Kakhovka Reservoir	2,155 km²	18,200 m³

Terraforming and damaged ecosystems

What the soviet propaganda remained silent about, however, was that the successes were achieved at the cost of very severe social and ecological consequences. The erection of these dams on the Dnipro River and the creation of large reservoirs for the dams were associated with the flooding of significant areas of land, which were both historically and culturally valuable but also held an enormous ecological role for biodiversity. In total, the Dnipro reservoirs have flooded 709,900 hectares of land. Among them, 197,600 hectares are sandy and unusable lands, 261,500 are forests and small woodlands, 177,600 are meadows and pastures, and 73,200 are arable lands, orchards, and estates (UNCG, 2023).

First and foremost, the creation of the cascade of water reserves essentially transformed the natural river flow into a series of lakes, also called “seas” in common parlance. These reservoirs altered the hydrological, hydrochemical, and hydrobiological regimes of the river and significantly affected the engineering-geological conditions of coastal zones, functionally transforming the ecosystem from a riverine to a lake-river system, leading to a corresponding slowdown in water exchange and self-purification, substantial water losses due to evaporation, and other changes (Texty, 2023). Due to the regulation of the Dnipro River, with 564 reservoirs created in the basin, areas of constant groundwater standing and flooding were formed. Thousands of rivers and streams found themselves below the level of the Dnipro, necessitating the construction of 34 pumping and compressor stations, which constantly pump water into the reservoirs (Texty, 2023). The silting of small rivers and the loss of their draining ability caused systematic flooding from 400 to 700 settlements and 60-200 thousand hectares of agricultural land (UNCG, 2023). Unique natural landscapes were destroyed. For instance, with the construction of the Kakhovka dam in 1956, the Great Meadow – a natural complex with forests, lakes, marshes and forests with its fishing and hunting grounds, which occupied up to 80,000 hectares — went underwater. For the species that lived in those territories, these changes were often fatal. Changes in the hydrological regime in the Dnipro caused a slowdown in water exchange and the pace of the river’s self-purification, while due to excessive evaporation of water, the river shallowed (Ukrainer, 2021). Across the entire Dnipro cascade, there is no fish passage facility, leading to the extinction of valuable fish species in the Dnipro River Basin and a significant decrease in fish populations in the Black Sea (Texty, 2023).

Figure 14. Photo from the construction of the dam for the Kyiv HES (early 1960s).
Author: unknown. Source: Ukrhydroenergo

Figure 15. Vovnihy village before being submerged underwater (1931)
Author: Mark Zalizniak; Source: Fund of the National Reserve “Khortytsia”

Sunken villages, flooded memories

At the same time, the loss of these vast territories not only meant the loss of the natural environment but also meant the relocation of thousands of people. *"Due to the planned flooding of the villages, all residents had to be forcibly evacuated and their homes and local architectural monuments demolished. The resettlement process lasted several years. […] A few years before the flood began, the state started ongoing felling and removal of trees. Some century-old oaks were cut down, buried in ditches and later flooded. The same happened with some churches, earthen fortresses and houses of the local population: some were demolished before the flood, the rest went underwater, and only some buildings were preserved. Most churches were destroyed so that their bell towers would not interfere with ships sailing there."* (Ukrainer, 2021).

Often, villagers had to destroy their own homes and cut down the trees on their plots, for which they received meagre compensation. Not only villages but also the city of Novoheorhiivsk were relocated. Nearly 10,000 of its residents, along with the inhabitants of the villages, moved to the new city of Khrushchev, later renamed Kremhres, and subsequently Svitlovodsk (Dovzhenko Centre, 2023). Altogether, only in the Kakhovka Reservoir, about 90 villages where at least 37,000 people lived ended up underwater (Texty, 2023b). Today, researchers can only approximately estimate the total number of flooded villages, as there have long been many small hamlets in the floodplains of the Dnipro River. Additionally, some settlements were merged during resettlement, some were partially relocated, and some were resettled but not submerged. According to various estimates, together with 261,000 square kilometres of forests, 177,000 pastures, 73,000 arable lands, gardens, and estates, over 2,000 churches, and 10,000 cemeteries, the number of flooded settlements ranging between 400 and 6000, with a total population of 282,000 and 3 million people respectively (Dovzhenko Centre, 2023). More recent research by Texty identified a more realistic and still significant total of 232 human settlements affected by the construction of HES after the construction of the six reservoirs. We strongly recommend having a closer look at their publication, which contains detailed maps and descriptions relating to each of the six water reservoirs. Of course, these lands and villages have preserved many traces of our ancestors' existence: burial mounds, graves, sanctuaries, settlements, treasures, and mammoth remains (Dovzhenko Centre, 2023). Along with the houses and churches, many old cemeteries and other monuments of the glorious past were flooded. To name just a few examples, the waters of the Kremenchuk Reservoir flooded the Neolithic and Bronze Age settlements discovered near the village of Morozivka; the village of Buzhyn, which was once a large city with 40 churches; and the village of Kryliv, which held Magdeburg rights during the times of the Hetmanate. With the construction of the Kyiv Reservoir, the village of Starosillia, mentioned in chronicles as far back as the times of Princess Olga and where Volodymyr Vernadskyi worked in the 1920s, also went underwater (Dovzhenko Centre, 2023).

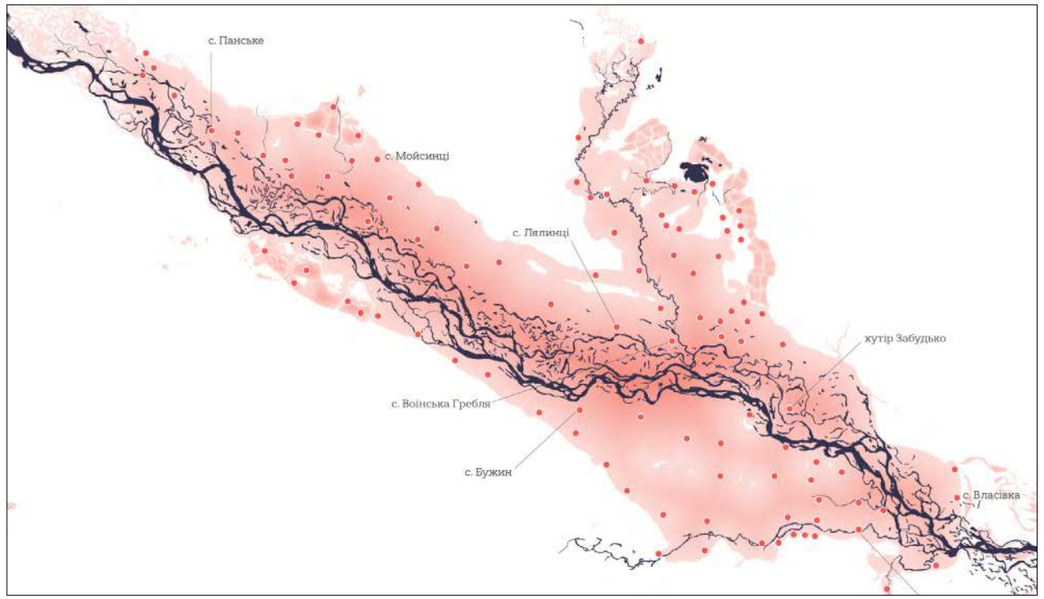


Figure 16. An excerpt of a map showing the villages (red) along the natural flow of the Dnipro River (dark), flooded during the construction of the Kremenchuk reservoir (light red). Author: Texty.org.ua, 2024

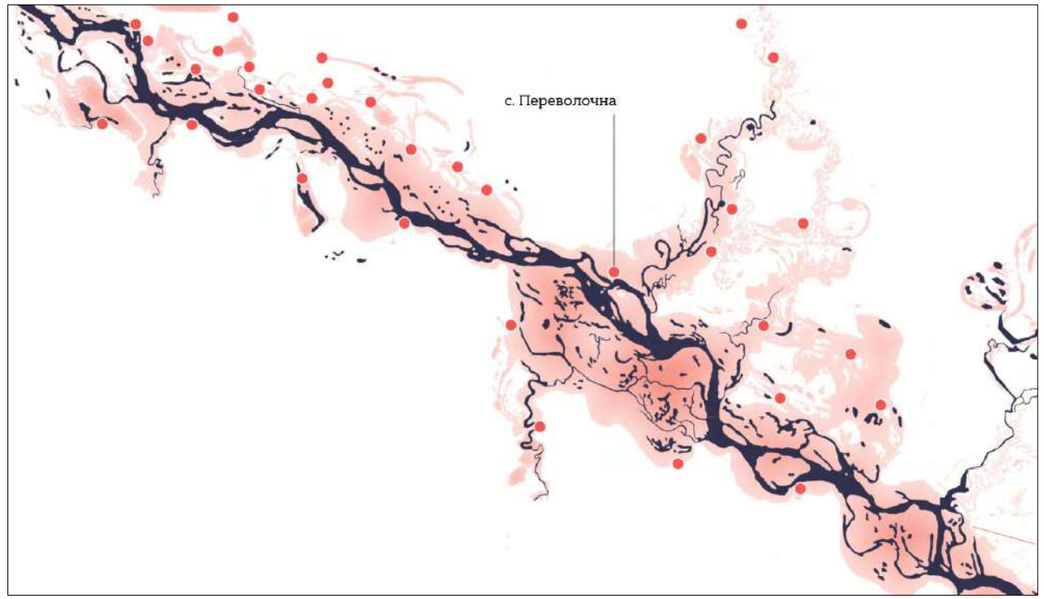


Figure 17. An excerpt of a map showing the villages (red) along the natural flow of the Dnipro River (dark), flooded during the construction of the Kamianske reservoir (light red). Author: Texty.org.ua, 2024

With the construction of the Kaniv Hydroelectric Station, the water took several Scythian burial mounds, the site of an ancient crossing between Trakhtemyriv and Pereyaslav and the locations of Monastyrok and Zarubintsy, associated with the Zarubintsy culture, discovered in 1899 by the Ukrainian archaeologist Vikentiy Khvoika. The famous villages of Andrushiv and Viunyshcha, where Taras Shevchenko stayed and wrote, also disappeared from geographical maps (Dovzhenko Centre, 2023). As for the Kakhovka Reservoir, the remains of old Cossack Siches, as well as the Great Meadow, which provided shelter for people during the Stalin-orchestrated man-made Holodomor-genocide and other famines in the decades that proceeded it, also submerged underwater (Texty, 2023b).

With all the physical and cultural relics, the waters of the reservoirs also swallowed the immaterial and intangible culture. For instance, the villages around the Great Meadow and the Dnipro Rapids, which were inhabited by the descendants of Cossacks who preserved unique Cossack toponymy — names of localities, rivers, hills, and forests — were lost, as names like Paliyivshchyna, Sirkivka, Vasurine, Stepok, Nalycach became obsolete (Texty 2023).

Many in Ukraine are still persuaded that in addition to purely pragmatic goals such as providing navigation, electricity and water supply for agriculture and the population, the creation of the Kakhovka and the other reservoirs had another goal: erasing the national memory of Ukrainians through the deliberate destruction of both material and immaterial culture.

Perhaps not without reason. At least from a propaganda perspective, one could say that the destruction of the Great Meadow was a massive blow to Ukraine and Ukrainian identity, “akin to taking away the Wailing Wall from the Israelis” (Texty, 2023b).

“The longing for the lost Cossack freedom, the dream of its return over centuries of occupation, gave Ukrainians the energy and motivation to fight. Everyone came out from the Great Meadow, from Shevchenko to the fighters of the UPA. Even during the period of Ukrainian reconstruction, the Cossack spirit continued to inspire Independence movements. Any movement for the freedom of the people must draw upon the glorious past without oppressors. In Ukraine, it is the Cossackdom of the Sich, which would not exist without the Great Meadow. And without the Cossacks and the Hetmanate, perhaps there would be no present-day Ukraine” (Texty, 2023b).

1.2.6. From the Soviet times into the modern days

Throughout the post-WW2 Soviet period, the river continued to be shaped and transformed to suit the various human needs. The centralised totalitarian system of the Soviet Union allowed grandiose projects to be built with extreme costs. These projects often delivered tangible results. The development of industry, agriculture, and the energy system continued to meet the growing demands of cities and their residents, as well as the Soviet military-industrial complex during the Cold War. These transformations came with significant benefits on the socio-economic level. However, they also came with significant limitations, challenges, and problems, especially regarding culture and environment.

Coming into its period of independence, Ukraine inherited both advantages and limitations from its Soviet past. The river continued to serve as a vital transportation artery, facilitating trade and commerce within Ukraine and with neighbouring countries. Its hydropower potential also remained a valuable asset for energy generation.

However, Ukraine also faced inherited challenges related to the management and environmental impact of the Dnipro River. Decades of industrialisation and agricultural practices during the Soviet era led to pollution and degradation of water quality, threatening both ecosystems and public health. Additionally, ageing infrastructure along the riverbanks required modernisation and maintenance to ensure efficient water management and flood control. Thus, while the Dnipro River offered numerous opportunities for economic development and sustainability, Ukraine needed to address inherited environmental and infrastructural challenges to fully harness its potential. These many topics become the subject of our next chapters.

1.3. Political geography

1.3.1. An international river

As discussed in the previous chapter, throughout the last several centuries, the Dnipro River remained in majority under a unified administration, without the complications of international borders affecting its management. It is true that for relatively brief periods during the First and Second World Wars, it had been controlled by the short-lived independent Ukrainian state (1919-1921) and by Nazi-German occupying forces in the early 1940s. However, in both instances, Ukraine's territories were subsequently incorporated into the Soviet Union, placing the entire river under Soviet control. The break up of the Soviet Union in 1991 changed that, bringing about the so-called internationalisation of the Dnipro River Basin.

Its upper reaches now found themselves flowing through the russian region of Smolensk, then swiftly crossing through Belarus before finally entering Ukraine. In Russia, the Dnipro River passes through the cities Smolensk and Dorohobuzh, in Belarus through Orsha and Mohylev, and aside from Gomel. At certain sections, the river and its tributaries serve as a natural border between countries, such as the left of Chernihiv, where the Dnipro River is shared between Ukraine and Belarus for 125km. In Ukraine, the Dnipro River crosses the country from north to south before finally flowing into the Black Sea.

Covering 48% of Ukraine's total surface, the Dnipro River Basin spans as much as 19 out of 26 oblasts (regions) of Ukraine and 281 administrative districts within them. It covers the entire territory of 6 regions – Zhytomyr, Chernihiv, Poltava, Dnipropetrovsk, Rivne, and Sumy, which together have 126 administrative districts. It partially occupies the territory of 13 other regions of Ukraine, including Vinnytsia, Volyn, Donetsk, Zaporizhia, Kyiv, Kirovohrad, Lviv, Mykolaiv, Ternopil, Kharkiv, Kherson, Khmelnytsky, and Cherkasy (DRBMP, 2023, p.15)

Figure 1. Map of the Dnipro River Basin
Authors: Elaborated by Ro3kvit and Greenpeace CEE

1.3.2. Density and demography

With its strategic, economic, and aesthetic advantages, the Dnipro River has long served as a magnet for settlement and human activity. Its expansive waterway provided crucial transportation routes for trade and communication, fostering the growth of thriving communities along its banks. The Dnipro River's strategic position as a natural barrier and navigable watercourse made it an attractive location for fortifications and defensive structures, shaping the course of regional conflicts and power struggles throughout history. The River's picturesque landscapes and scenic beauty have captivated artists, poets, and travellers, inspiring cultural and artistic endeavours that have further enriched the region's heritage. As a result, settlements along the Dnipro River have flourished, becoming centres of trade, culture, and innovation.

Many settlements, villages, towns and cities have their origins in the distant past, including the capital Kyiv, Pereyaslav, and Rzhyshchiv, which evolved and transformed from the Middle Ages and throughout the centuries. Others have a less distant history, founded or significantly developed during the Russian Empire or during the Soviet Union. All these cities contribute to the vibrant tapestry of Ukraine's history and civilization.

As of January 1, 2017, the population in the Dnipro River Basin was 20.7 million people, which amounted to almost half of the total population of just below 45 million (EUWI+, 2020). Today, it is hard to estimate the exact population due to the ongoing war and population movements; however, providing the overall decrease of the population to an estimated 36-38 million, a reduction is expected accordingly. Despite this, the share of the population living in the Dnipro River Basin remains very significant in proportion to the total population of Ukraine, highlighting the importance of the River in the demographic composition of the country.

With an urbanisation rate in Ukraine of just below 70% in 2021 before the russian full-scale invasion, the majority of the population within the Dnipro River Basin lived in urban areas, accounting for 74%. In total, there are 192 cities within the basin, and around 50 of them are situated on the banks of the Dnipro River itself. The capital and largest city of Ukraine — Kyiv — alone accounts for 2.84 million people in 2021, according to official data, growing to just under 3 million in 2022. Other large urban areas after Kyiv include Dnipro (just over 1 million), Zaporizhzhia (0.77 million), Kherson, Kremenchuk, and Kamianske (all three around 250 thousand), all situated along the Dnipro River, but also Kryvyi Rih (0.66 million people), and Mykolaiv (0.50 million people) are within the river basin.

The rural areas account for the remaining 26% of the population. These include 329 urban-type settlements with a total population of 1.63 million people; 546 villages with a population of 210,492 people and 14,029 villages with a population of 6,498,118 people. The average population of villages in the Dnipro River basin is 463 individuals.

Figure 2. Photo of the Kyiv riverside, 2008
Author: Dmitry A. Motti; Source: Wikipedia.org (CC BY-SA 3.0)

Figure 3. Map of major Ukrainian cities in along the Dnipro River
Author: Elaborated by Ro3kvit and Greenpeace CEE

1.4. Legal status

1.4.1. Transboundary rivers: Global context

Water knows no borders. Yet, over half (52%) of the global population lives in transboundary river and lake basins (World Bank, 2023). That is, river and lake basins that are shared between two or more countries. All basins differ in size, political complexity, hydrological conditions, etc. In total, there are 276 identified transboundary basins, shared by 148 countries, which account for as much as 60% of the global freshwater flow (World Bank, 2022). Among them, 33 countries have more than 95% of their territories within the hydrological boundaries of one or more international basins (DRSWQ, 2015).

But, while hundreds of rivers are shared between two or more countries, more than half of the world's 310 international river basins and all but five transboundary aquifers lack intergovernmental cooperative agreements (World Bank, 2023). Some parts of rivers are governed and managed under one policy framework, while other parts of the same river may be regulated under a completely different set of policies. More broadly, the complex physical, political and human interactions within international river basins can make the management of these shared water systems particularly difficult.

How this may, and sometimes does, translate into practice is that the natural asymmetry of upstream users can often lead to tensions over water resource management. In simple terms, actions in one country have consequences in another. For instance, "overexploitation and pollution of lakes, rivers, and aquifers can jeopardise ecosystem services across borders," while "a unilateral move by one country to build a dam could drastically reduce a river's flow downstream in another country" (UN Water). While the challenges of fragmentation are often replicated at the national scale within countries, the differences in the political and legal frameworks between states arguably make it harder to organise water resource management in an efficient way for all users, but also in a more sustainable way that accounts for the future generations.

Water is such a fundamental asset that competing human, economic, social and biological needs inevitably make rivers a natural source of competition and, in extreme cases, of conflict between riparian states. Some recent examples of tensions that emerged on the ground of water resource management include the river Indus (Pakistan and India), the Euphrates–Tigris (Turkey, Syria and Iraq), the Nile (Egypt, Sudan and Ethiopia) basin and others (Pieternel de Bruin et al., 2022). In literature or media, such tensions are often referred to as "water conflicts". Although it is hard to find a war that was fought solely on the grounds of water resource management, access to water — a vital resource — has undoubtedly played a major role in many conflicts around the world throughout history. A 2012 publication of the US National Intelligence Council outlining global megatrends, based on a mapping of environmental water scarcity, concludes that "water may become a more significant source of contention than energy or minerals out to 2030 at both the intrastate and interstate levels". The fact that the highest degree of water stress is expected to emerge in shared river basins raises the potential for interstate conflict (DRSWQ, 2015)

Today, in the context of climate change and growing demand for scarce water resources, proactive management of transboundary waters is becoming both more complex and more urgent (World Bank, 2023). According to UNICEF, already today, about 4 billion people experience severe water scarcity at least one month a year, while as close as by 2025, half of the world's population could end up living in water-scarce regions (UNICEF, 2020). According to estimates, implications may include the migration of up to 700 million people around the world, which inevitably comes with severe pressures for many other sectors, the built environment and various resources, as well as push millions into poverty.

At the same time, tensions from transboundary waters are also escalated by climate change, as 90% of climate disasters are said to be water-related, dominating the list over the past 50 years (UNDRR, 2024; World Bank, 2022). During this time, floods, landslides, storms, heat waves, wildfires, extreme cold, droughts and waterborne disease outbreaks have all become more frequent (increasing by a factor of five) but also more intense, accounting for 70% of all deaths relating to natural disasters (UN Water).

1.4.2. Transboundary rivers: the need for international cooperation

While water can lead to disputes, “history tells us that shared water can also be an important source of cooperation.” “Major international rivers have spurred significant collaboration among the countries sharing their waters, although these relationships require continued nurturing” (World Bank, 2023). As Wolf (1998) identified, the 507 conflict-related events over water in the period between 1960 and 2010 were “grossly outnumbered by the nearly 1300 cooperative events (treaties, projects, institutions, joint initiatives, etc.) (DRSWQ, 2015). Because water is vital for the economic and social well-being of entire regions, transboundary cooperation is not only desired but is most likely a necessity.

While there is no legally binding international legislation that guides international cooperation regarding transboundary rivers, among the main treaties and policy frameworks, we can identify two important agreements: the UN Water Convention (1992) and the UN Watercourses Convention (1997). The 1992 UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes entered into force in 1996. With the aim of promoting sustainable management of water resources and the prevention of conflicts, the Water Convention requires parties to enter into basin agreements and establish joint bodies, complementing any existing bilateral or multilateral agreements. Initially developed for the pan-European region, the convention was amended in 2003 to allow accession by any UN member state since 2013 (DRSWQ, 2015, p.20). The Convention on the Law of the Non-navigational Uses of International Watercourses was adopted in 1997 and entered into force in 2014, setting up the first global legal framework for cooperation over water resources between countries. The convention was ratified by 36 countries.

Apart from major UN conventions, various governmental and non-governmental institutions exist, tasked with providing guidance and support in dealing with issues related to water at all levels. These include the OECD, the Global Water Partnership, but also the World Water Council. Within the UN itself, while there is no dedicated specialised agency, water policy issues engage some 31 Un bodies.

Transboudary river in Europe

With the highest number of international river basins in the world, as well as some of the most complicated ones, the European continent also has one of the most extensive and sophisticated elaborate systems of transboundary water governance. A pan-European and the EU treaty framework builds on a long history of cooperation and shared political priorities. In addition to the UNECE Water Convention, the centrepiece of EU water legislation includes the Water Framework Directive (WFD), adopted in 2000.

Based on the concept of integrated river basin management and representing an overhaul of previous water policy, the WFD offers input for best practices in transboundary water management (PA, 2004; DRSWQ, 2015, p.23). While it remains a reference system rather than a formal requirement, the WFD is supported by an elaborate system of political and technical bodies administered by the European Commission that has produced a broad range of guidance and other resource documents. However, it has also served as a key document for the development of individual river basin management plans, which have contributed to the resolution of transboundary river management (DRSWQ, 2015, p.25).

The Danube River basin

As the second largest river basin in Europe, touching a territory of 2000 km2 in 19 countries (including Ukraine) and connecting around 80 million people, the Danube River Basin is perhaps one of the best examples of international cooperation in transboundary water management (ICPDR, 2021). Stemming out of the intergovernmental 1994 Danube River Protection Convention, the International Commission for the Protection of the Danube River (ICPDR) developed management plans for the whole Danube River Basin, providing a clear framework for international cooperation (PA, 2004). Around the world, the ICPDR is seen as a world leader in river basin management, providing valuable lessons for the managers of other transboundary water systems as Danubian countries managed to turn the hydrological and political complexities of the basin into a source of exemplary cooperation and integration.

Since 2009, the Danube River Management Plan (DRBM) has provided a roadmap which, among others, fulfils the EU Water Framework Directive (WFD). The most important indicators used include the existence of a formal basin or cooperation agreement, the existence of a basin organisation, the degree of application of international water law, national and regional political stability, mechanisms to manage uncertainties (data collection and sharing, hydrological variability management, risk planning, etc.), environmental quality management, presence of major hydraulic infrastructure, geographical features of the basin, other linkages between riparians, etc (DRSWQ, 2015).

1.4.3. The Dnipro River in Ukrainian law

According to Article 13 of the Constitution of Ukraine, land, water, and other natural resources within the territory of Ukraine are objects of the right of ownership of the Ukrainian people. Article 1 of the Water Code of Ukraine defines water resources as the volumes of surface water, groundwater, and marine waters within the respective territory. Surface waters, in turn, comprise natural water bodies (lakes), water flows (rivers, streams), separate water bodies (water reservoirs, ponds), channels, and other water bodies (FAO), also divided into objects of national and/or local significance (Article 5 of Water Code of Ukraine) (NECU, 2020). At the same time, an essential component of water bodies is the land on which they are located and bounded. According to the Land Code of Ukraine (Article 58, Part 1), the lands occupied by water bodies — namely, rivers, reservoirs, other water bodies, coastal protective strips, canals, and banks of waterways — are considered to be part of the water fund (NECU, 2020).

Depending on the basin's drainage area, rivers are categorised as small (less than 2,000 km²), medium (from 2,000 to 50,000 km²) and large (over 50,000 km²). This division entails different measures aimed at their preservation (NECU, 2020). With a drainage area of 291.4 thousand km² only on the territory of Ukraine, covering fully or partly the area of 19 regions, the Dnipro River is, of course, a large river of national significance. In Ukraine, water resources are protected by the state. Thus, water management involves an inter-sectoral interaction of various state institutions that conduct, among others, the monitoring of water usage, water accounting and water conditions (biological, hydro morphological, chemical, and physicochemical indicators). These include the following (see Table 1):

Table 1. National institutions engaged in water resource manegemnt and related activities

State Agency of Water Resources
State Fishery Agency of Ukraine
State Environmental Inspectorate
State Environmental Inspectorate
Ministry of Environmental Protection and Natural Resources
Ministry of Agrarian Policy and Food of Ukraine
Ministry of Infrastructure of Ukraine
Ministry of Economic Development and Trade of Ukraine
Ministry of Energy and Coal Industry of Ukraine
Ministry of Regional Development, Construction and Housing, and Communal Services of Ukraine
Ministry of Agrarian Policy and Food of Ukraine
Ministry of Health of Ukraine
Ukrainian Geological Survey

1.4.3. The Dnipro River and international cooperation

During the years 1992-2001, bilateral intergovernmental agreements on water management in border waters were concluded by Ukraine with all neighbouring countries (including Poland, Belarus, Moldova, Romania, Slovakia, and Hungary) based on the provisions of the UN Convention on the Protection and Use of Transboundary Watercourses and International Lakes. The agreements cover a wide range of issues, including water resource management and utilisation, protection from harmful effects of water, water quality monitoring, information exchange, search and design work, water management and conservation measures (DAVR, 2017).

In the first decades of Ukraine's independence, various international initiatives in the sphere of water management were initiated, some related specifically to the Dnipro River basin. For instance, in 1995, the Ministers of Environment from the Republic of Belarus, the Russian Federation, and Ukraine signed the Memorandum on Cooperation for the Dnipro Basin Rehabilitation, expressing their intention to work together and pool their resources (UNDP-GEF, 2004). On the basis of this document, financial support and technical assistance were sought from the Global Environment Facility (GEF) for the development of the international programme for environmental rehabilitation of the Dnipro Basin. A Strategic Action Programme (SAP) for the Dnipro Basin and the mechanisms for its implementation were developed within the framework of the UNDP-GEF Dnipro Environment Programme, which involved a Transboundary Diagnostic Analysis (IWlearn, 2007; GEF, 2014; Balashenko et al., 2003).

These steps towards transboundary cooperation between the three states sharing the Dnipro River basin were confirmed in 2003 in Kyiv during the fifth Pan-European Conference "Environment for Europe" with a Ministerial Declaration on Cooperation for Environmental Rehabilitation of the Dnipro Basin, signed by the three riparian countries. In this Declaration, the Ministers of the Environment expressed their "willingness and preparedness to develop the international agreement that will provide a common framework for ensuring the sustainability of international cooperation between the riparian countries of the Dnipro Basin, and establishing the common principles, objectives, tasks and obligations of the parties in the field of environmental rehabilitation of the Dnipro Basin" (UNDP-GEF, 2004)

Towards European Integration

In 2015, Ukraine ratified the UN Water Convention (UNECE, 2015), making the environmental impact assessment and monitoring a requirement for its transboundary rivers (including the Dnipro River) to prevent, limit and reduce any transboundary impacts (necu.org.ua, 2020). An important element of Ukraine's international water cooperation was participation in international technical assistance projects. From 2016 to 2021, as an EU candidate country, Ukraine participated in the EU Water Initiative Plus for the Eastern Partnership (EUWI+4EaP), which focused on bringing national legislation and strategies in line with the EU Water Framework Directive, in particular on the question of integrated water resource management and the management of transboundary river basins (DAVR, 2017). Article 4 of the Directive requires Member States to use their River Basin Management Plans (RBMPs) and Programmes of Measures (PoMs) to "protect and, where necessary, restore water bodies in order to reach good (chemical and ecological) status, and to prevent deterioration" (European Commission, 2023). Hence, one of the main objectives of the project is the development and implementation of RBMPs, building on an improved policy framework and ensuring a strong participation of local stakeholders.

In 2016, integrated approaches to water resources management based on the basin principle were introduced in Ukraine. In 2017, the boundaries of river basins, sub-basins, and water management areas were approved. As mentioned in the sections above, the Dnipro River Basin is divided into five sub-basins: Upper, Middle and Lower Dnipro sub-basins, as well as two sub-basins based on Dnipro's largest tributaries, Desna and Prypiat. Each of the sub-basins has a corresponding basin council, which, however, acts only as an advisory bodies.

Table 2. Main international and national legislation related to water resources management

1991	Law of Ukraine On Environmental Protection
1994	Convention On the Protection of the Black Sea from pollution
1994 (UPD: 2023)	The Code of Ukraine on Subsoils
1995 (UPD: 2023)	The Water Code of Ukraine
1999	Law of Ukraine On Ukraine's Accession to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes
1992–2001	Ukraine's Bilateral cooperation agreements in the sphere of transboundary water resource management
2002 (UPD: 2024)	The Land Code of Ukraine
2002	Convention On the cooperation in the Protection and Sustainable use of the Danube River
2003	Protocol on Water and Health to the Convention on the Protection and Use of Transboundary Waterways and International Lakes

1.4.5. Impact of Russia's war against Ukraine on Water Policy

Russia's military aggression on Ukraine, since its illegal occupation of Crimea in 2014 and especially since its full-scale invasion in 2022, has had a fundamental role in the country's integration with the European Union. Indeed, Ukraine's path towards the EU has been significantly accelerated by the events of the Russo-Ukrainian war, leading to broad social and political changes. On the political level, this process has been reflected in the development and implementation of a series of policy reforms aimed at bringing Ukrainian legislation in accordance with broader EU rules, strategies and standards, as described above. Questions over the management of water resources were not an exception.

Whilst actively continuing to cooperate on matters of water with its European neighbours and the European Union at large, bilateral relations with the Russian Federation and Belarus have become increasingly complicated and unviable. Practically, the cooperation between Russia and Ukraine in the exchange of information on transboundary water bodies was halted in 2014 after Russia invaded Crimea and started a war in the Donetsk and Luhansk regions. Officially, the Ukrainian government announced the decision to terminate the 30-year diplomatic relations with Russia in the sphere of water relations in December 2022. The decision comes as no surprise as Russia not only openly and bluntly violated the Agreement on the joint use and protection of border water bodies, but it "undermined everything created in the field of water policy over the years of Ukraine's independence", according to the Minister of Environmental Protection and Natural Resources of Ukraine Ruslan Strilets (DAVR, 2022).

Since 2022, Russia has committed a series of atrocious crimes, including specifically targeting critical water infrastructure on the Dnipro River, destroying the Kakhovka Dam, and causing severe ecological and economic damage to Ukraine. In this context of ongoing ecocide and genocide, it is indeed hard to imagine any bilateral or multilateral agreements in the sphere of transboundary water resource management (as in any other area) between Ukraine and Russia and Belarus, who are fundamentally undermining Ukraine's territorial and political sovereignty by their act of military aggression. Multilateral agreements in the form of international commissions or international basin organisations, as was done with the Danube River, for instance, are very unlikely to be seen in the current realities.

Despite the devastating scale of the damage already inflicted on the Dnipro River and Ukraine, it is important to understand that the lack of transboundary cooperation and the broader context of the ongoing war make the Dnipro River not only a target for the Russian terrorist aggressor state but also a weapon of war. This report is rather not the place to enumerate and discuss in detail all the potential scenarios related to the weaponisation of the Dnipro River. However, with the current realities, it is important to remember that such threats exist and pose significant risks for the communities and biodiversity of the Dnipro River and Ukraine by and large.

Amid the war, Ukraine continues its accelerated path towards European integration. The first drafts of management plans for nine river basins have been developed and published throughout 2023, supplemented by programmes of measures that take into account post-war recovery (EU4Environment, 2023). As the largest river in Ukraine, the Dnipro River too has received significant attention. In December 2023 the State Agency of Water Resources of Ukraine has published the Dnipro River Basin Management Plan 2025–2030 (DAVR, 2023).

Part 2
The Dnipro River as a source of life

Contents

Summary

It is difficult to overestimate the importance of the Dnipro River for Ukraine. It is probably no exaggeration to say that the Dnipro is as integral to Ukraine's existence, as water is for life on earth. On the one hand, the Dnipro's water sustains a rich diversity of natural ecosystems, habitats, and various species of plants, animals, and microorganisms. At the same time, the Dnipro also provides vital processes for the existence of our human species. History shows that over centuries and millennia, the Dnipro's water has contributed to the development of numerous civilizations, kingdoms, empires, and states. Today, the Dnipro River continues to play an important role in the daily lives of millions of Ukrainians, not only because of its role in the development of the natural environment that we depend on, but also because it helps to meet a variety of human water needs, from agriculture to industry, energy production, shipping, tourism and recreation. Last but not least, the Dnipro is also an important cultural symbol that has inspired and united Ukraine for centuries, and without which it is perhaps impossible to imagine Ukraine.

Understanding what role the Dnipro actually plays in Ukraine's economic, social and political well-being is essential to formulating relevant, comprehensive and contextualised strategies for the river's future development. This section provides a detailed overview of all the major functions that the Dnipro River plays in our lives. We start with the first layer, namely the natural environment, exploring how the Dnipro basin contributes to the development of flora and fauna and biodiversity in general. In the following sections, we gradually cover the various topics already mentioned above, including agriculture, industry, energy production, transportation and navigation, and the recreational aspect of the Dnipro river. We will look at the role the Dnipro plays in these different areas, how important its water is, and whether it is possible to do without it. In the last section we turn to the topics of culture and heritage, citing some of the many works associated with the Dnipro River, both historical and more contemporary, forcing the reader to think about how we perceive the river more generally in the context of Ukrainian culture, history, and identity.

2.1. Natural environment and biodiversity

2.1.1. Historical context

Above all else, water is an essential element for life on Earth. It is part of a complex natural ecosystem composed of plants, animals, fungi and other living organisms that depend on water. While our ancestors did not possess the sophisticated tools we have today to record and analyse the environment, the earliest written accounts about the Dnipro River suggest that the river and its basin stood out long ago as a place where flora and fauna were distinctively thriving. Back in 450 BC, Herodotus described the Dnipro River as "the most productive" river, adding that:

> *"it provides the finest and best-nurturing pasture lands for beasts, and the fish in it are beyond all in their excellence and abundance. Its water is most sweet to drink, flowing with a clear current, whereas the other rivers are turbid. There is excellent soil on its banks, and very rich grass where the land is not planted; and self-formed crusts of salt abound at its mouth; it provides great spineless fish, called sturgeons, for salting, and many other wonderful things besides"* (*The Histories*, Book 4, Chapter 53).

Many centuries later, the Ukrainian writer and historian Adrian Kashchenko would echo Herodotus in his article about *The Great Meadow and the Zaporozhian Cossacks*. Published in 1917 with the help of the Commission for the Study of the Local Region of the *Yekaterinoslav Scientific Society*, the historical-geographic study provides a detailed overview of Dnipro River's flora and fauna, including fish, animals, birds, insects and plants. Below are some excerpts from the work:

> *"In the waters of the Great Meadow, giant sturgeons swam, measuring up to 18 cubits (3 fathoms)* [~5.5 meters] *in length, so heavy that barely six Cossacks could lift one onto their shoulders; under the cliffs, in the eddies, smooth, thick-headed catfish hid, while sturgeons, whitefish, and sterlets swam in whole herds; enormous, well-fed carp and long, toothy pikes glittered there against the sun with golden and silver scales; in the water, schools of fish played: zander, bream, crucian carp, perch, tench, eels, burbot, ruffe, flounder, ide, and vendace, and the river was never calm from the smaller fish. […]*
>
> *In the Great Meadow, there were wolves, wild boars, deer, wild goats (sugaks), foxes, badgers, hares, martens, stoats, beavers, minks, and buzzards, and finally, during the autumn season, steppe inhabitants also came here — wild horses. […]*
>
> *Birds thrived here the best. The chirping and twittering were so pervasive that even in the 19th century, people could barely hear each other. The Dnipro meadows were once gleaming white from pelicans and sea gulls; swans, wild geese, cormorants, and ducks sometimes obscured the water in the lakes; cranes, storks, and herons majestically and calmly roamed the swamps; the shores of the estuaries teemed with countless sandpipers; the curly trees of the Meadow became a shelter for doves, cuckoos, grouses, hoopoes, starlings, magpies, swifts, nightingales, goldfinches, woodpeckers, and other singing and non-singing birds, whose peace was only disturbed by falcons, hawks, buzzards, and giant eagles. […]*
>
> *And how many bees there were, freely swarming on trees and even in the reeds."*

Throughout the centuries, the Dnipro River has changed a lot due to natural transformations, but more importantly, due to anthropogenic activity and human intervention. Along with the growing urbanisation on the river banks, the industrial revolution of the XVIII and XIX centuries extensively developed river navigation, as well as the growth of heavy industries and large-scale agricultural activity, all of which had to various extents inflicted damaging impacts on the ecosystems in and around the river.

Most significant of all, however, was the erection during the Soviet Empire of the six hydroelectric power plants (dams) along the Dnipro River, transforming it into a cascade of reservoirs, often called seas for their large size. Thousands of hectares of land, home to thousands more species, were flooded and submerged under the waters, destroying ecosystems. Nonetheless, while these changes occurred (and more discussion about these will follow in the next parts of this book), the Dnipro River and its basin continue to be a place with a distinctively important role in the ecological biodiversity of Ukraine, Europe and the world at large.

2.1.2. Ukraine's biodiversity: Overview

The UN Convention on Biological Diversity defines the term biodiversity as "The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (EEA, 1997). Essentially, this includes the whole variety of life forms on Earth, ranging from mammals, birds, reptiles, amphibians, fish, insects, invertebrates, plants, fungi, algae, and micro-organisms, but also the variability of genes and forms within a species, and their assemblage into habitats and ecosystems.

This intricate natural web is essential for maintaining balance and supporting life. It is hard to overestimate the importance of biodiversity, as while nature is declining at an unprecedented rate, the loss of biodiversity threatens not only endangered species but every life on Earth. That is why the preservation of biodiversity plays such an important part in the UN Sustainable Development Goals, namely the *SDG15 Life on Earth* (UN, 2023).

Occupying less than 6% of the area of Europe, Ukraine possesses as much as 35% of its biodiversity.

In part, this can be explained by its favourable location featuring diverse natural zones and various migration routes. Ukraine's biota comprises over 70,000 species, including many rare, relict and endemic species. Many flora and fauna species in need of special protection are included in the Red Data Book of Ukraine (the most recent edition of the Red Data Book of Ukraine (2009) contains 826 species of flora and 542 species of fauna) (CBD, no date).

Thanks to the efforts of various organisations and initiatives, including the Ukrainian Nature Conservation Group, Zoï Environment Network, CEOBS, UN Environment Programme, and many others, today we can have a more comprehensive and informed understanding of the natural and ecological biodiversity in Ukraine and in the Dnipro River Basin in particular. As the main water artery passing across Ukraine from north to south, and with a river basin covering almost half of the country's total surface, the Dnipro River plays a significant ecological role. The sections below provide a more detailed analysis of the biodiversity of the Dnipro River Basin by looking at the flora and fauna.

A detailed view at flora, fauna and fungi in the Dnipro River basin: Research methodology and data

Sources	The analysis of a series of open source geospatial data for Ukraine provided by Global Biodiversity Information Facility website allowed us to develop a general picture of the distribution and variety of species and biodiversity across the Dnipro River Basin. The data and visualisations presented in the sections below were elaborated from a large amount of datasets from various publishers including ecological NGOs, public crowdsourcing companies and academic institutions. Some of the biggest contributors of the data are as follows:
• *Animals*	Cornell Lab of Ornithology, Ukrainian Nature Conservation Group (NGO), iNaturalist.org, European Bird Census Council (EBCC), PlutoF, I. I. Schmalhausen Institute of Zoology, Azov-Black Sea Ornithological Station, Ukrainian Bat Rehabilitation Center, Adam Mickiewicz University in Poznań, West-Ukrainian Ornithological Society
• *Plants*	M.G. Kholodny Institute of Botany, Kherson State University, Centro Internacional de Agricultura Tropical, Bioversity International, Zhytomyr Ivan Franko State University, State Museum of Natural History of the National Academy of Sciences of Ukraine.
Methodology	The data is compiled and reduced to the borders of Dnipro River Basin. After the exclusion of identical records with repeating attributes we have a total account of 332,115 records of animal species, 326,563 records of plant species, 27,490 records of fungi.
Acknowledging limitations	It is important to point out that, despite the large sets of documented species, these datasets likely do not cover the full biodiversity represented in the Dnipro River Basin, as both limited technological capacity and human bias are impossible to fully avoid. That said, the data available should be taken as indicative of the general ecological situation, with an understanding that a more detailed and comprehensive analysis would probably note an even richer biodiversity.

2.1.3. Protected Areas (PAs)

Protected areas are a common method in the toolkit of national government or international organisations for identifying ecologically significant regions.

They play a crucial role in conserving biodiversity, preserving ecosystems, and safeguarding important natural and cultural resources. Protected areas can come in various forms, including national parks, wildlife sanctuaries, marine reserves, wilderness areas, and others, often depending on local policy context. These areas are designated and managed with specific regulations to minimize human impact and maintain ecological integrity. By establishing protected areas, governments and conservation organizations aim to balance human needs with the long-term health of ecosystems and the species they support.

There are three major types of protected areas in Ukraine. First, there is the Nature Reserve Fund, which refers to natural areas protected by Ukraine's national law. Second are Areas of Special Conservation Interest (otherwise known as the Emerald Network), brought together and endowed with a single conservation status for the whole of Europe. Last but not least, the so-called Ramsar sites are part of an international treaty that provides the framework for the conservation and wise use of wetlands and their resources. These three frameworks are discussed in more detail below with specific reference to the Dnipro River basin.

Figure 1. A drone photo of the Trakhtemyriv peninsula in the Kaniv Reservoir on the Dnipro River, Regional Landscape Park *Trakhtemyriv* (Cherkasy region); Author: Oleksandr Malyon

Figure 2. Photo of the Kozachiy Island on the Dnipro River in Kyiv
Author: V. Vlasenko, 2009; Source: Wikipedia.org (CC BY-SA 4.0)

i. The Nature Reserve Fund of Ukraine

As stated in the Law on the Nature Reserve Fund of Ukraine, the Nature Reserve Fund covers those parts of land and water objects with special environmental, scientific, aesthetic, recreational or other value for Ukraine. These territories are singled out to preserve the natural biodiversity of landscapes and species, maintain the general ecological balance and ensure background monitoring of the environment. The most important types of protected areas, part of the Nature Reserve Fund of Ukraine, are:

- *Biosphere Reserves* are created with the intent of conserving the most typical natural complexes of the biosphere in a natural state, conducting background ecological monitoring, and studying the surrounding natural environment and its changes under the activity of anthropogenic factors.
- *Nature Reserves* are created with the goal of conservation in a natural state typical or unique for a given landscape zone nature complexes with the entire collection of their components, efficient use of natural resources, and ecological safety.
- *National Nature Parks* are created to conserve, restore, and effectively use natural complexes and objects that have special environmental protection, health-oriented, historic-cultural, educational, and aesthetic value.
- *Regional Landscape Parks* are created to conserve typical or unique natural complexes and objects and provide the conditions for organized recreation for the population.

As of January 2020, according to the State Cadastre of Territories and Objects of the Nature Reserve Fund of Ukraine, the NRF covers 8512 territories and objects with a total area of 4.418 million hectares within the land area of Ukraine and 402.5 thousand hectares within the Black Sea. The ratio of the actual area of the Nature Reserve Fund to the area of the state ("reserve indicator") is 6.77% (Bondarenko and Kyryliuk, 2021). The total number of Nature reserve fund territories in the Dnipro River basin is 3,637, with a total area of 22,093 square kilometres, corresponding to 7.50% of the basin's total area within Ukraine.

There are a total of 279 areas of national importance in Ukraine, covering 7.67% of the total number of protected areas. Among these, within the Dnipro River Basin are 2 Biosphere reserves, 7 Nature reserves, 19 National nature parks and 21 Regional Landscape parks. Almost half of these protected areas are located along the Dnipro River. Among the most significant areas of national importance connected to the Dnipro River Basin are the Chornobyl Radiation and Ecological Biosphere Reserve, the Black Sea Biosphere Reserve, the Kaniv Nature Reserve, Dnipro-Oril Nature Reserve, the Velykiy Luh National Park, the Kamianska Sich National Nature Park, the Biloozerskyi National Nature Park and others.

Another important indicator highlighting the importance of the Nature Reserve Fund is the concentration of species. Our research, based on pre-2022 data, has identified within the areas of the Nature Reserve Fund 340 of the 524 protected animal species, 350 of the 589 protected plant species, and 19 of the 38 protected and rare fungi species.

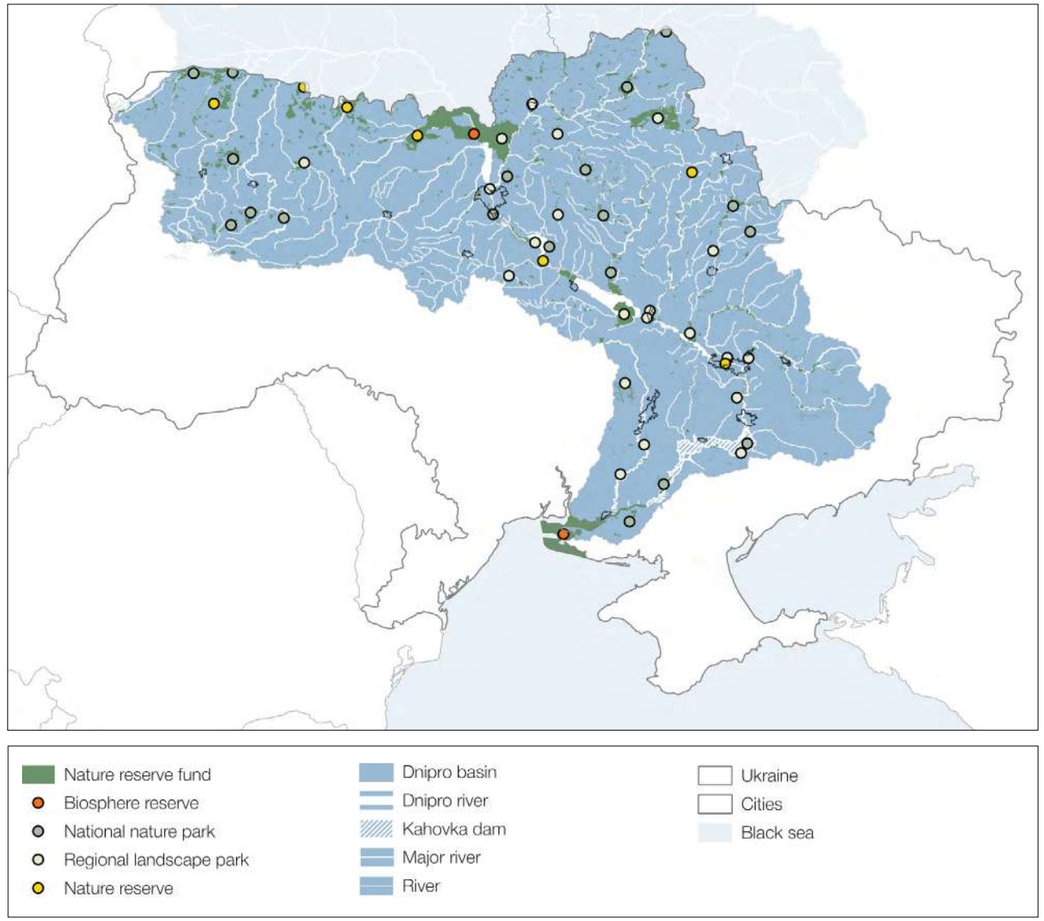


Figure 3. Map of Protected areas under the Nature Reserve Fund of Ukraine
Author: Elaborated by Ro3kvit and Greenpeace CEE

ii. The Emerald Network

The Emerald Network is a European-wide protected area network established to protect species and habitats threatened to become extinct on a continental scale. This network is designed to comply with the Bern Convention requirements (UNCG; EEA). The Emerald Network is an apt name for a network of Areas of Special Conservation Interest (ASCI) in Europe. These areas were brought together and endowed with a single conservation status for the whole of Europe. To be granted this status, an area must provide an adequate level of protection for habitats and flora and fauna species that have been identified as European priorities (UWEC, 2023).

Currently, within Ukraine, the Emerald Network consists of 271 sites, covering around 10% of the country's surface, compared to an average of 18% for the EU countries (UNCG). Using the geospatial data from the Water Agency of Ukraine, it is estimated that within the Dnipro River Basin, there are 147 already adopted Emerald network areas with an area of 37 778 square kilometres, equivalent to 13.16% of the basin's total area. In addition to that, 58 areas with a total area of 10 479 square kilometres had been proposed for adoption before the war. If the proposed areas are approved, the Emerald network will cover 16.4% of the Dnipro River basin.

The Dnipro Ecological Corridor is one of the largest ones in Ukraine and has transboundary significance. The priority is to study the region's flora, fauna, and natural habitats to preserve and reproduce the rare components of biotic and landscape diversity (Solomakha et al., 2020).

The Emerald Network responds to these tasks by including almost the whole Dnipro River. However, the upper parts of Kaniv and Kamianske reservoirs are not part of the protected zone, although these areas, where the islands and floodplains exist, are critical in terms of biodiversity.

Spatially, the Dnipro River is the unifying foundation that connects the other elements of the Emerald network. Heading out of the Dnipro River as the central axis, other lineal areas run mainly along the major tributaries in the Dnipro River Basin, forming the protection network. The primary purpose of the Emerald network is to ensure the conservation of the most valuable and typical components of landscape and biotic diversity, including habitats of rare and endangered animals and plant species. Within the Emerald network, 439 of all 524 protected species of animals, 476 out of 589 protected plants, and 35 of all 38 protected or rare fungi can be found. This underlines the importance of the Emerald network and the need for its expansion to protect endangered species and ecosystems.

Besides all the pros of the Emerald Network, there is one major weakness: unlike national parks and reserves, the protection status of the Emerald Network does not restrict any agricultural activities. The last time new Emerald network areas were proposed was in 2020, but these have still not been approved due to the ongoing war. The aim of Ukrainian ecological organisations such as UNCG – a leading actor in assessing, suggesting and protecting the areas – is to expand the Emerald Network to 20% of the area of Ukraine and elaborate feasible management plans for the sites.

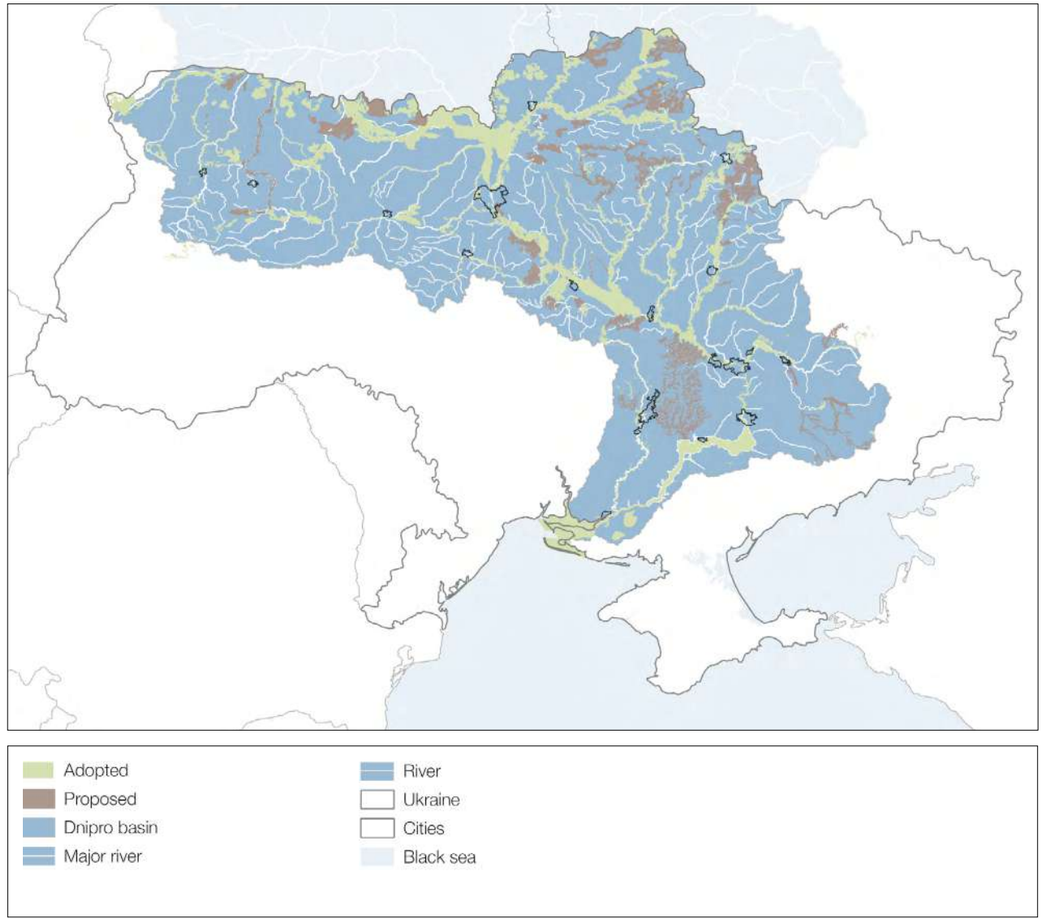


Figure 4. Map of Protected areas under the Emerald Network in Ukraine
Author: Elaborated by Ro3kvit and Greenpeace CEE

ii. Ramsar Sites

The Convention on Wetlands is an intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources. It was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975. Since then, almost 90% of UN member states have acceded to become "Contracting Parties." Ukraine has been part of the Convention since 1991. As of writing this report, there are 50 Ramsar sites with a total surface area of 9,305 square kilometres.

Within the Dnipro River Basin, there are 14 Ramsar sites with a total area of 1,853 square kilometres. Nine of these are located in the northern periphery of the Basin, while the other five, including the two biggest, are situated in the lower reaches of the Dnipro River itself. These include the Dnipro River delta, the Yahorlytska Bay, the Archipelago Velyki and Mali Kucguhury, the Dnipro-Oril Floodplains, and the Sim Mayakiv Floodplain, covering together an area of 865,7 square kilometers (see https://rsis.ramsar.org).

- *The Dnipro River delta* includes swampy areas, floodplain forests, sandy ridges and a lake complex. The diverse vegetation consists of hydrophilic communities, islands of floodplain forest, and reed thickets, all of which provide essential habitats for endemic and nationally rare species.
- *Yahorlytska Bay* – this Black Sea bay consists of several islands, saline lakes and temporary water bodies. It is one of the least-disturbed wetlands in the Black Sea coastal region. It supports a high level of biodiversity with many endemic species.
- *Dnipro-Oril Floodplains* – this floodplain terrace at the confluence of the Dnipro and Oril Rivers is one of the last remaining pristine floodplain landscapes along the Dnipro. Nonetheless, depending on discharges from the upstream and downstream reservoirs, the site's water level fluctuates considerably. Some 40 fish species, including the sterlet (*Acipenser ruthenus*), are recorded.
- *Archipelago Velyki and Mali Kuchugury* –this site consists of an archipelago of sandbank islands ("big" and "small" Kuchugury), as well as the surrounding shallows in the upper reaches of the Kakhovka Reservoir in the floodplain of the Lower Dnipro River. It is an important nesting location for wetland bird communities. The wetland used to be of great importance as a natural filter of fresh water within the ex-reservoir.
- *Sim Mayakiv* – The site is composed of a unique karst system atypical of southern Ukraine and its flat steppe areas. A deep tertiary river channel with a small steppe river forms a unique complex of floodplain forests, wet meadows and reed beds where it meets the Kakhovka reservoir. The wetland constitutes a unique refugium for biodiversity in the steppe region: 137 species of birds, 24 species of mammals, 47 fish, 690 insects and 326 species of plants have been recorded at the site.

Figure 5. Map of Protected wetlands under the Ramsar Convention in Ukraine
Author: Elaborated by Ro3kvit and Greenpeace CEE

iv. Conclusions

With 2 Biosphere reserves, 2 Nature reserves, 6 National nature parks and 11 Regional Landscape parks located along the Dnipro River (10 of these holding National importance), the Nature Reserve Fund accounts for 7.50% of the total area of the Dnipro River Basin (compared to the 7.40% average for EU-27) (EEA, 2023).

At the same time, the Emerald Network occupies 13.16% of the basin's surface (compared to an 18.6% average for EU-27), with 147 adopted sites located wholly or partly within its limits (EEA, 2023).

Given the national and transboundary significance of the Dnipro Ecological Corridor, the Dnipro River is almost entirely included in the Emerald Network. Albeit, the upper parts of Kaniv and Kamianske Reservoirs are not part of the protected network despite their high ecological biodiversity.

While itself ecologically important, the Dnipro River also plays the role of a unifying foundation and the central axis that connects the other elements of the Emerald network. While many sites have been adopted in previous years, about 58 proposed sites with a total area of 10,479 square kilometres still await formal recognition. If adopted, they will expand the Emerald network to 16.4%, nearing the EU-27 average.

Last but not least, Ramsar sites occupy another 0.62% of the Dnipro River Basin with 14 sites in total: nine in the north of the basin on Dnipro's tributaries, and five directly on the Dnipro River in the lower reaches, covering an area of 865,7 square kilometres. When compiled together, the total share of Nature Reserve Fund, the Emerald Network, and Ramsar sites amounts to 18.68%, compared to 26% for EU-27. This percentage is lower than the sum of the different PAs as there is some territorial overlap between the different types, which is excluded from the calculation.

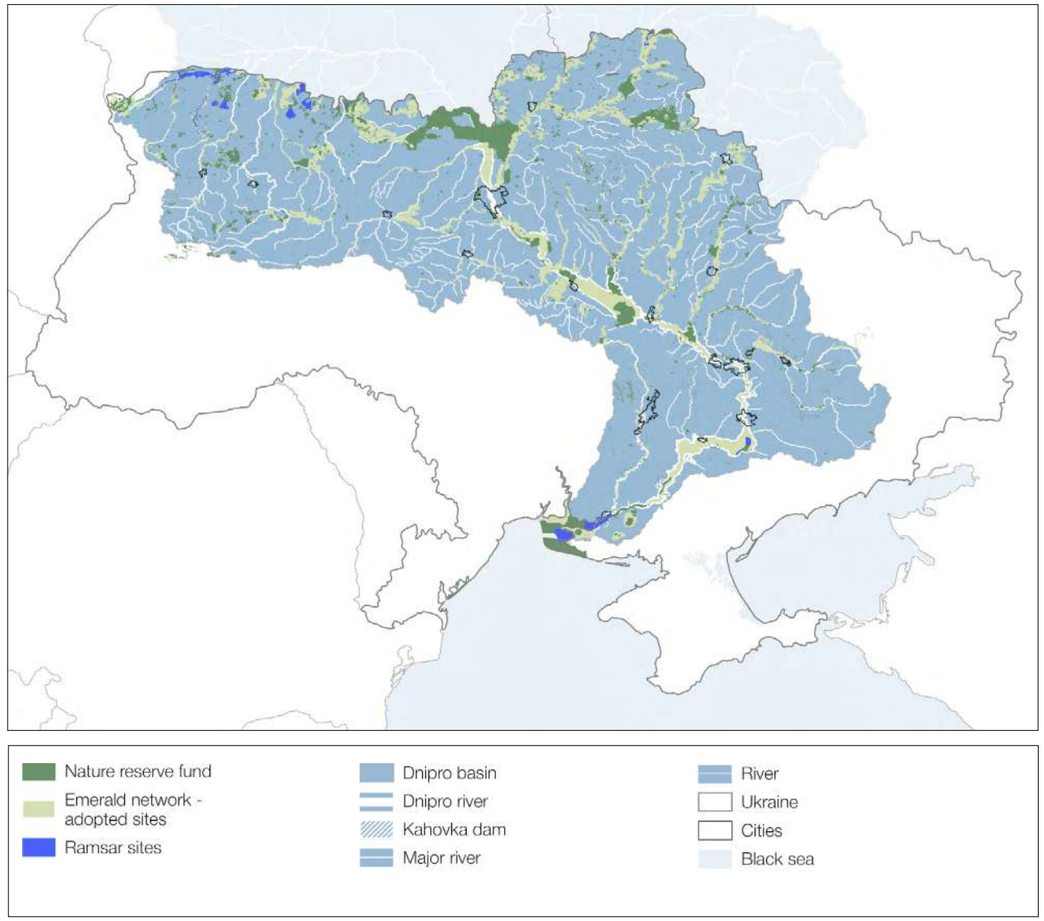


Figure 6. Map of all Protected Areas in Ukraine
Author: Elaborated by Ro3kvit and Greenpeace CEE

2.1.4. Flora

Analyzing the data for plant diversity, we can state that the Dnipro River Basin has a unique richness of Flora with 3,562 unique plant species that are part of 259 plant families recorded. More than 98% of all plants (~3,500) are vascular species, which is one and a half times more than the registered vascular plants in the Danube River basin, which hosts around such 2,000 species (ICDPR, 2017). According to the class they belong to, 69.3% of the species are Dicotyledons (*Magnoliopsida*), 17% are Monocotyledons (*Liliopsida*), 4% are Moses (*Bryopsida*) and others.

In total, there are 326,563 records, covering 259 unique plant families. The plant families are distributed relatively evenly, which is a sign of the rich plant diversity within the Dnipro River basin. Spatially, plants are also relatively evenly distributed around the territory of the Dnipro River basin.

Within a 10 km buffer from the Dnipro River, 2,588 species (73%) of all plants and 199 protected or rare species (34%) of all protected or rare plants were recorded. This highlights the great importance of the river itself for the fauna and ecosystems within its basin.

The main hotspots for the concentration of plants are Kyiv and areas around the city. Beyond the capital, there are three main axes with a high number of recorded plants:

- towards the north, along the Desna and Snov rivers;
- towards the south, along the Kaniv reservoir;
- and towards the north-west until the Drevlyanskyi Nature Reserve.

Furthermore, some other single hotspots can be traced within the Desnyansko-Starogutskyi National Nature Park, Zhytomyr and its surroundings and areas south of Cherkasy, around the Hydrological reserve Irdyn swamp.

Figure 6 visualizes the diversity of plant species, combining all public geospatial data available on the Global Biodiversity Information Facility website (see *www.gbif.org*). It is important to note that despite the huge number of documented plants, there is still a chance that a given species is missed or just not documented. That said, the area's biodiversity should be considered even richer than the analyses below.

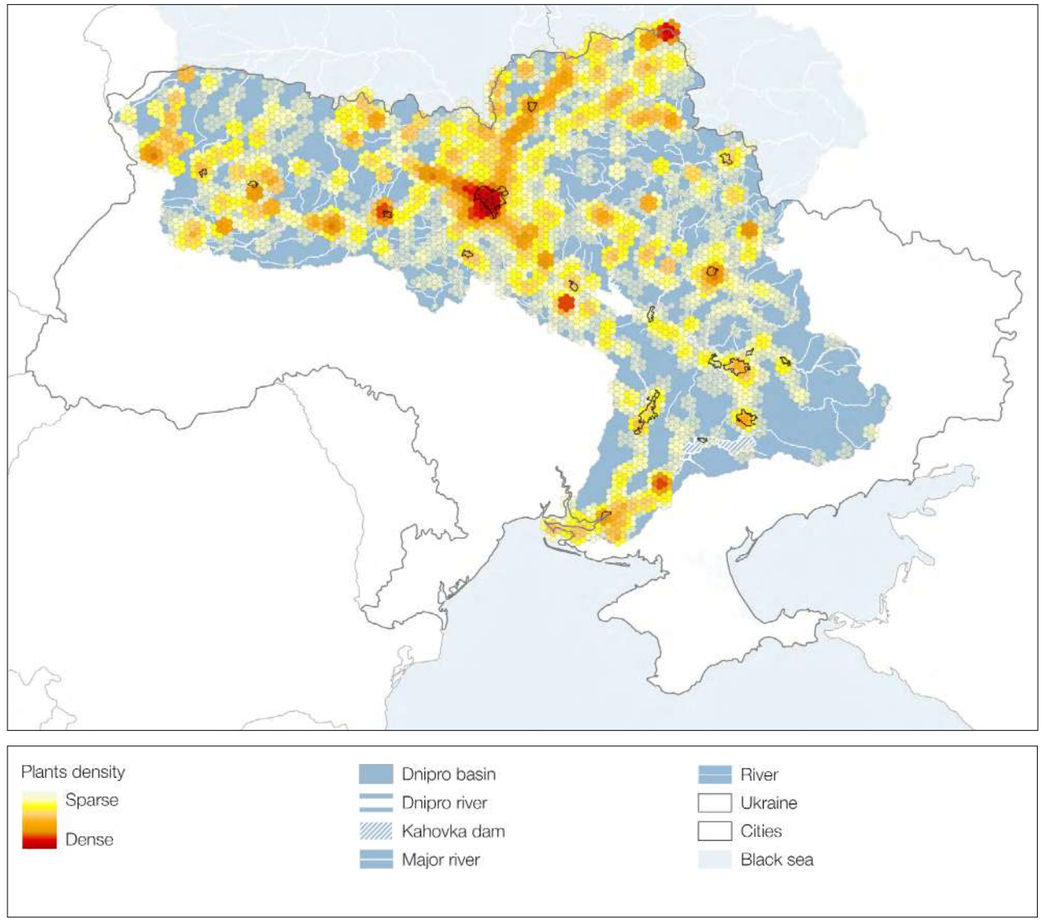


Figure 7. Map of all plant density within the Dnipro River basin
Author: Elaborated by Ro3kvit and Greenpeace CEE

i. Rare and protected plants

Based on the information compiled from four datasets (Bern Convention, The Red Book of Ukraine, the Conservation Biology of Ukraine, and the Open Biodiversity Project), we have been able to construct a better spatial understanding of the distribution of rare and protected plants, taking into account identical records and dataset duplicates.The map illustrates 9,511 records of protected and rare plants. This spatial distribution makes it possible to conclude that these species are predominantly located in the eastern and southern parts of Dnipro River basin.

Several major hotspots should be highlighted - Kyiv area heading south to Kaniv reservoir, Kryvyi Rih and areas on the north, east and south along Inhulets river, several hotspots on the south of Rivne, areas along Dnipro reservoir. A total of 589 unique protected and rare plant species, part of 93 families, are recorded in the Dnipro River basin. This includes two endangered species - Aldrovanda vesiculosa (Waterwheel plant) and Agropyron dasyanthum and one critically endangered species - Betula klokovii, with a total count of around 50 trees left.

Figure 8. Photo of Nymphaea alba in the Dnipro River near the Trukhaniv Island in Kyiv, 2021
Author: Alexey Iaa; Source: Wikipedia.org (CC BY-SA 4.0)

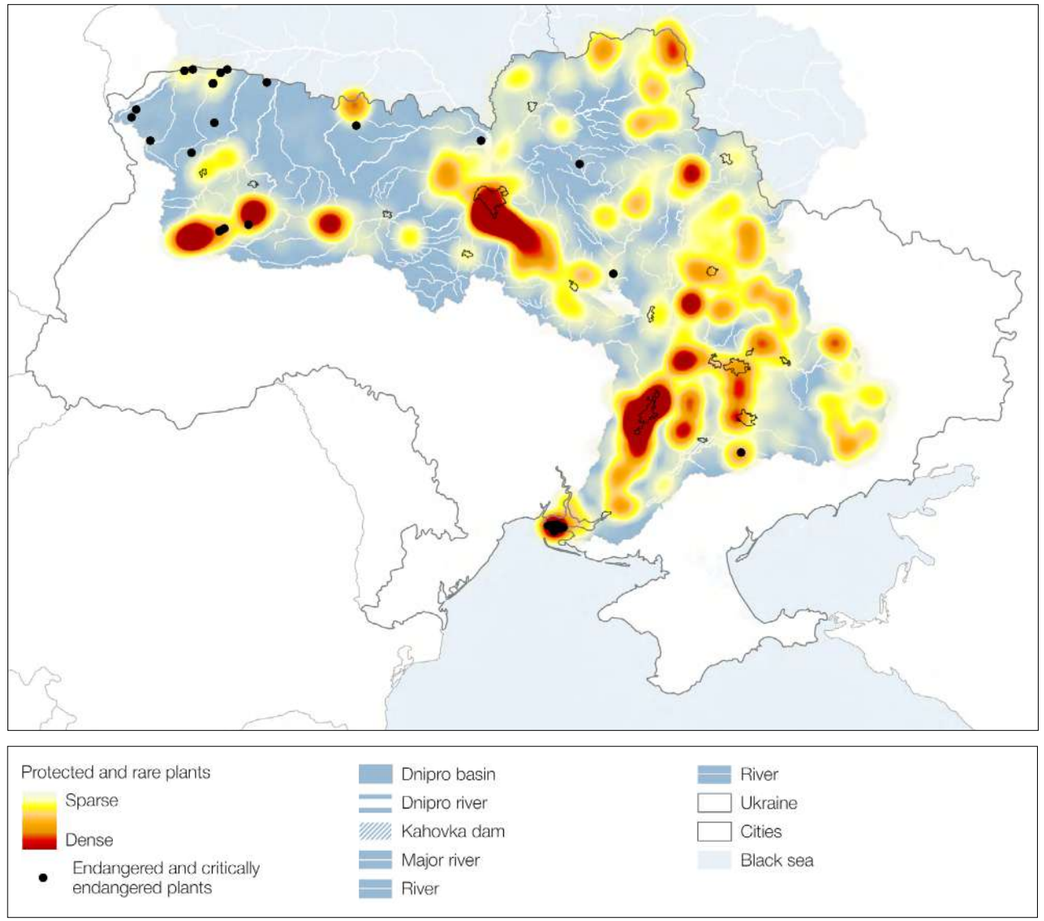


Figure 9. Heatmap of rare and protected plant species in the Dnipro River basin.
Author: Elaborated by Ro3kvit and Greenpeace CEE

ii. Invasive alien plants

Invasive alien plants (IAP) accelerate the local extinction of native species (Islam et al., 2001), disturb trophic structure, create resource scarcity and alter ecosystem services and ecosystem health (Rai, 2015; Rai and Singh, 2020) and change ecosystem function (D'Antonio and Vitousek, 1992; Fensham et al., 1994). The impacts of IAPs on biodiversity include increased parasitism, predation, novel habitat formation, economic loss (Linders et al., 2019) and reduced agricultural productivity and forest diversity.

In total, 236 alien plant species are recorded in 57 families. There is a relatively equal amount of number of species that are most recorded - Small Balsam, Sosnowsky's hogweed, Annual ragweed, Boxelder maple, Eastern daisy fleabane and Canada goldenrod, which are almost half of all records made. Spatially, most of the significant hotspots with a high concentration of alien plants are located in urban areas - Kyiv, Kryvyi Rih, Zhytomyr, Rivne, Lutsk, Chernihiv, Bila Tserkva and areas south of Cherkasy.

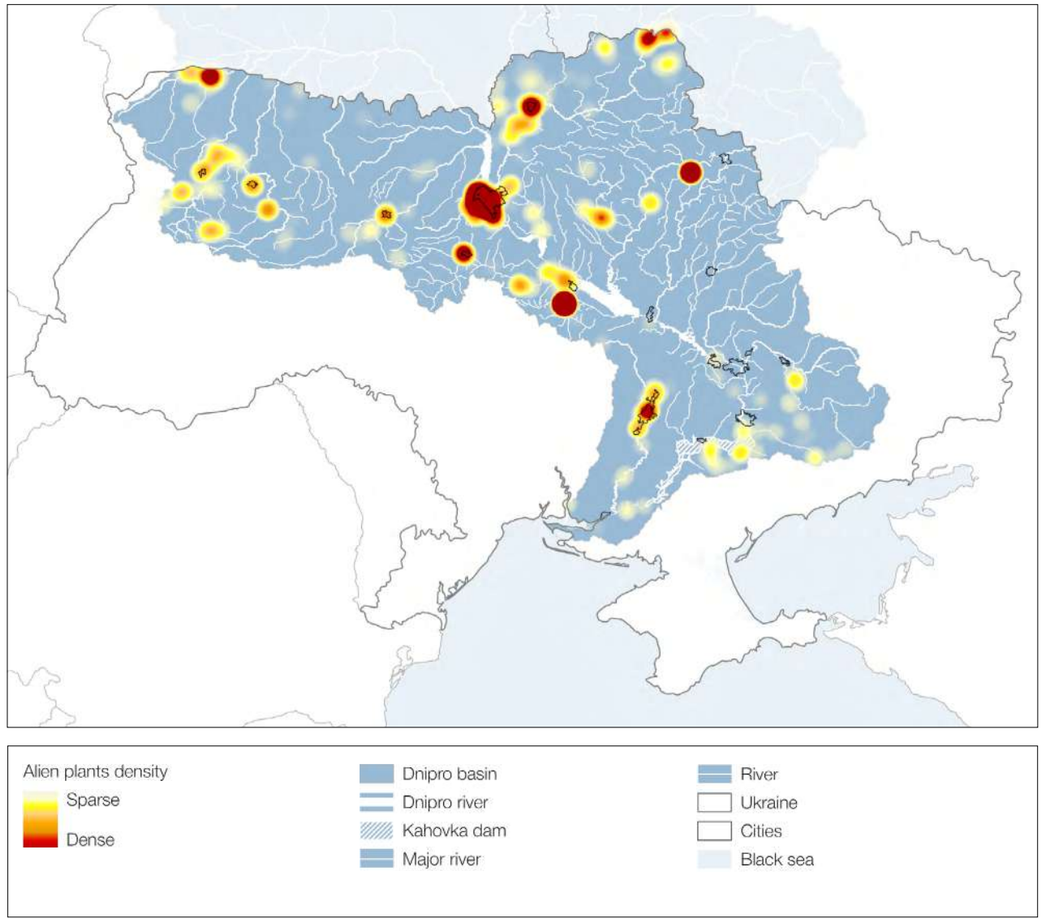


Figure 10. Heatmap of alien plant species in the Dnipro River basin
Author: Elaborated by Ro3kvit and Greenpeace CEE

2.1.5. Fauna

Along with its diversity of plant species, the Dnipro River Basin boasts a remarkable richness in animal life. Our analysis identified 8,114 unique animal species in the studied area. For comparison, the Danube River Basin hosts around 5,000 animal species (ICDPR, 2017). The documented records are predominantly from Birds (195,010 records) and Insects (71,897), followed by Fish (26,413), Mammals (12,670), Amphibians (6,208), Gastropods (5,810), Reptiles (4,023), Arachnids (3,875), and Annelid worms (2,265). According to their class, 75.9% of the species are Insects, 6.4% are Birds, 5.9% are Arachnids, 1.9% are Gastropods, 1.8% are Fish, 1.7% are Mammals, 1.6% are Annelid worms, and 4.7% belong to other smaller classes.

The fauna of the Dnipro River Basin exhibits distinct patterns of spatial concentration. Notably, the area around Kyiv serves as a focal point for the diversity of animal species. Moving outward from Kyiv, there is a consistent pattern of high animal concentration along the Desna River and its tributary, the Seym. Further south along the Dnipro River, other hotspots with high species concentrations include the areas along the Kaniv Reservoir and around the cities of Kremenchuk, Kamianske, Dnipro, and Zaporizhzhia, as well as the Dnipro delta and estuary.

The concentration of species is markedly higher in the northern and central parts of the river basin. Possible reasons for this include (1) a higher density of rivers in these regions; (2) the predominance of forest and forest-steppe landscapes in the north and centre, compared to the steppe, semi-arid, and arid steppe landscapes in the south; and (3) a lower number of records collected in the south due to the war. This pattern is also evident in the Kyiv area and its surroundings, where the highest number of records is likely due to more active observation and monitoring of nature, including efforts by educational and administrative institutions.

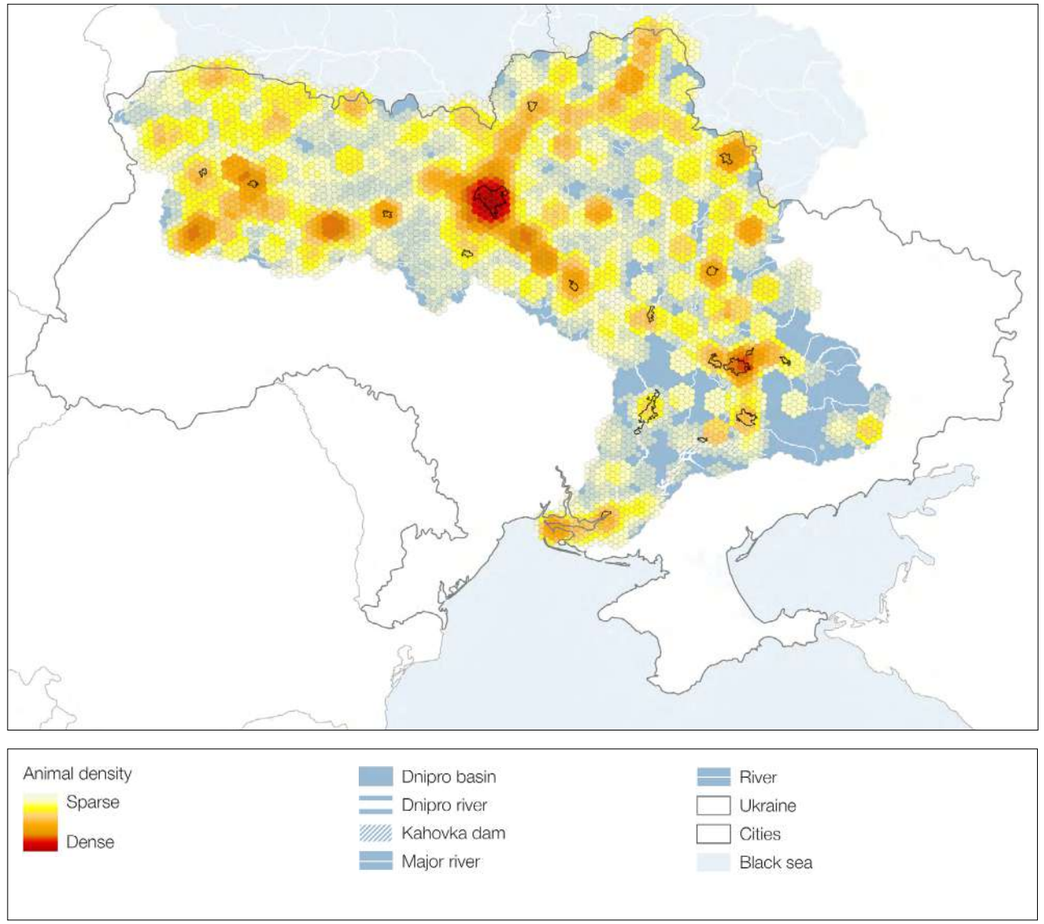


Figure 11. Density heatmap of animal species in the Dnipro River basin.
Author: Elaborated by Ro3kvit and Greenpeace CEE

Figure 12. Photo of Ciconia Ciconia on Muromets Island on the Dnipro River (Kyiv region), 2015
Author: Aimaina Khikari; Source: Wikipedia.org (CC0)

Figure 13. Birds on the Dnipro River in Kyiv on a frosty day, 2021
Author: Kiyanka; Source: Wikipedia.org (CC BY-SA 4.0)

Figure 14. Photo of a Dragonfly Emperor in the reeds thicket near on the Dnipro River in Kyiv, 2009
Author: V. Vlasenko; Source: Wikipedia.org (CC BY-SA 3.0)

Figure 15. Photo of Tavolzhanin Island on the Dnipro River (Zaporizhzhia region), a nesting site of the great cormorant (Phalacrocorax carbo), 2016. Author: Artyom Zherebtsov; Source: Wikipedia.org (CC BY-SA 4.0)

i. Mammals

It is estimated that there are 93 unique species of mammals, 62 rare or protected, in the Dnipro River Basin. Most of them are different species of bats and small mammals (mainly rodents), but there are also significant numbers of records of Wolves, Red foxes, Eurasian lynxes, Roe deer, Eurasian beavers, Brown hares, European badgers, and others.

The total number of mammals in Ukraine is 112, which means that 83% of all mammals in the country have been observed in the Dnipro River Basin (World Rainforests, 2023). Records of 2 critically endangered mammal species—Russian desman and European hamster—have been made, mainly in areas west of Kyiv.

Also, there is a record of the endangered Przewalski's horse north of the capital. Six species of alien mammals have been registered within the Dnipro River Basin.

Spatially, most of the mammals are localized mainly in the eastern parts of the basin, as well as along the river itself. It is interesting to point out that along the river, there are alternating points of high concentration of mammals in natural and urban areas - Mizhrichynskyi Regional Landscape Park, Kyiv area, the upper part of Kremenchuk reservoir, areas between Kremenchuk and Kryvyi Rih, Kamianske and Dnipro, Zaporizhia and Dnipro delta and estuary.

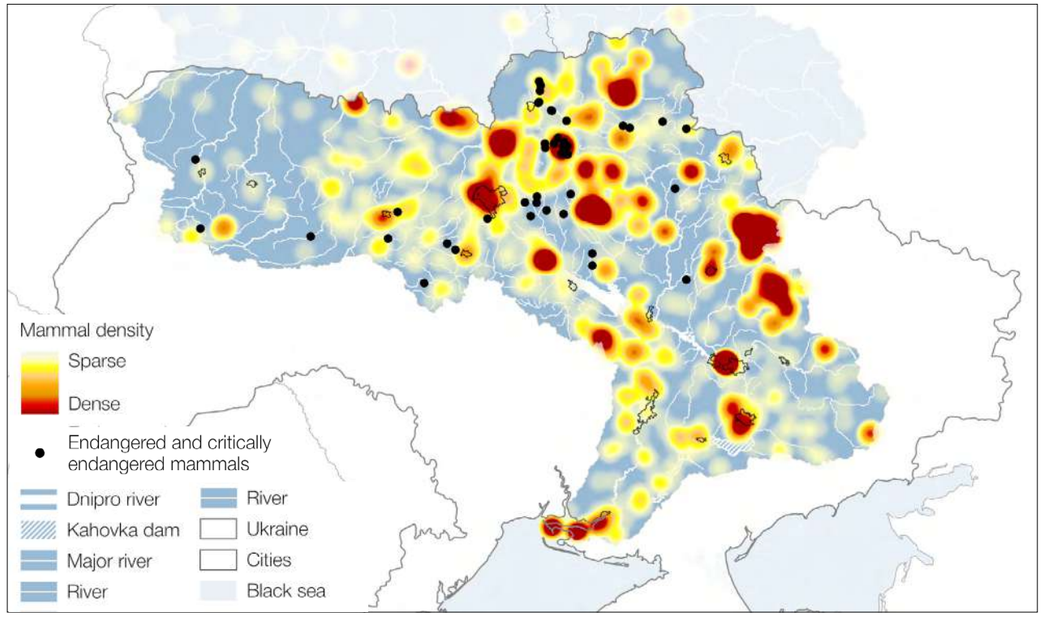


Figure 16. Density heatmap of mammal species in the Dnipro River basin.
Author: Elaborated by Ro3kvit and Greenpeace CEE

ii. Birds

In order to illustrate the variety and spatial distribution of Birds in the most precise way, information from three datasets is combined: eBird observation, INaturalist, and Ukraine Nature Conservation Group datasets. It is important to note that used datasets do not have information if the records are made for transition, winter stays, or nesting stay. This means some species registered could follow the river as the transitional pass, but that doesn't mean the birds stopped in the outlined area.

In total, as many as 362 species of birds have been observed in the Dnipro River Basin, according to the observed data, equivalent to 80% of all bird species in Ukraine (452). Among these, 162 are protected species of birds — "national birds of Ukraine", as well as three endangered species included in the International Union for Conservation of Nature's Red List of Threatened Species – the Saker falcon, the Great Bustard and the Egyptian vulture (IUCN, 2023). Last but not least, three alien species of birds are recorded.

Generally, most of the records are of birds that are typical for this part of Europe, such as the Great tit, Eurasian magpie, Hooded Crow, Mallard, Eurasian Chaffinch, Eurasian tree sparrow, etc. Spatially, most of the birds are predominantly registered in the north-west part of the Dnipro River basin, with some hotspots along the river itself - around the cities of Kyiv, Dnipro, Cherkasy, and in the Dnipro delta.

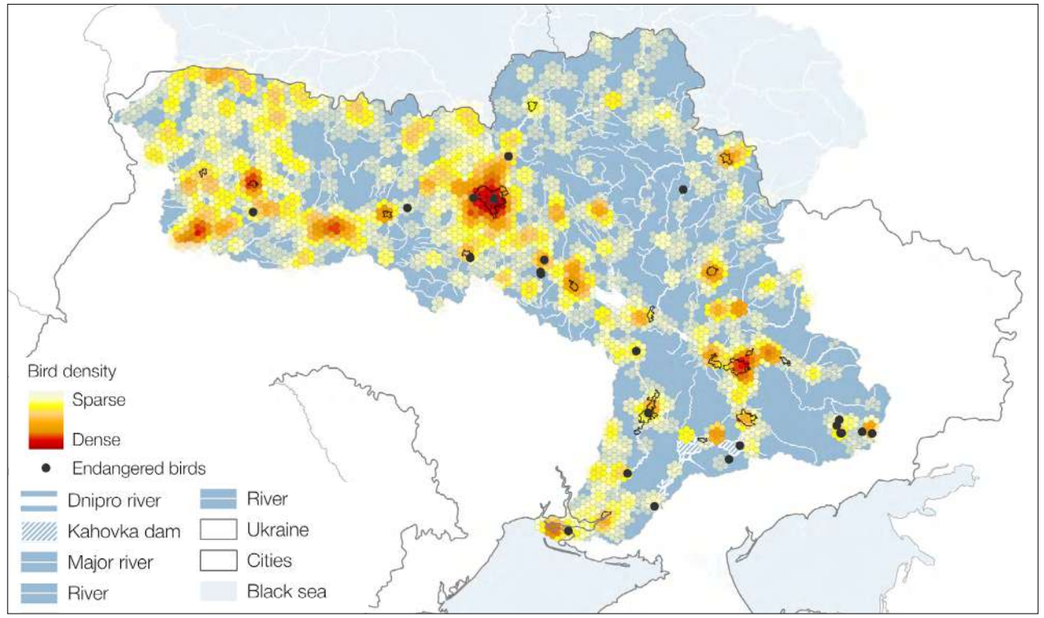


Figure 17. Density heatmap of bird species in the Dnipro River basin.
Author: Elaborated by Ro3kvit and Greenpeace CEE

iii. Fish

The fish database includes four different datasets. As a result, 23,715 records of 106 different species of fish are represented on the map. Most of the recorded species are Common roach, Common bleak, Rudd, European perch, northern pike, Kolblei, and spined loach. There are records of one endangered species (Sterlet) and four critically endangered ones — starry sturgeon, Russian sturgeon, European eel, and Beluga. There is a visible spatial pattern of distribution which shows that most of the occurrences are located in the north and central parts of the basin - along the Dnipro River (Kyiv, Kaniv, Kremenchuk and Kamianske reservoirs) and its tributaries on the left bank - Desna, Snov, Seym, Oster and some significant parts of Sula, Psel and Vorskla rivers.

The massive imbalance in the records between the north and south may be due to the lower density of water bodies in the southern part of the Dnipro Basin and the frontline along the southern parts of the Dnipro River. Even if there were records in this part of the river - they certainly would not be up-to-date because of the incident with the Kakhovka dam, which changed the morphology of the river. Invasive fish can dramatically alter food web structures, decreasing the food available for native species. This leads to direct competition, population declines in native species, and loss of biodiversity. It is estimated that there are 46 recorded species of invasive fish in the Dnipro River basin, most located along the river in the areas between Kyiv and Dnipro.

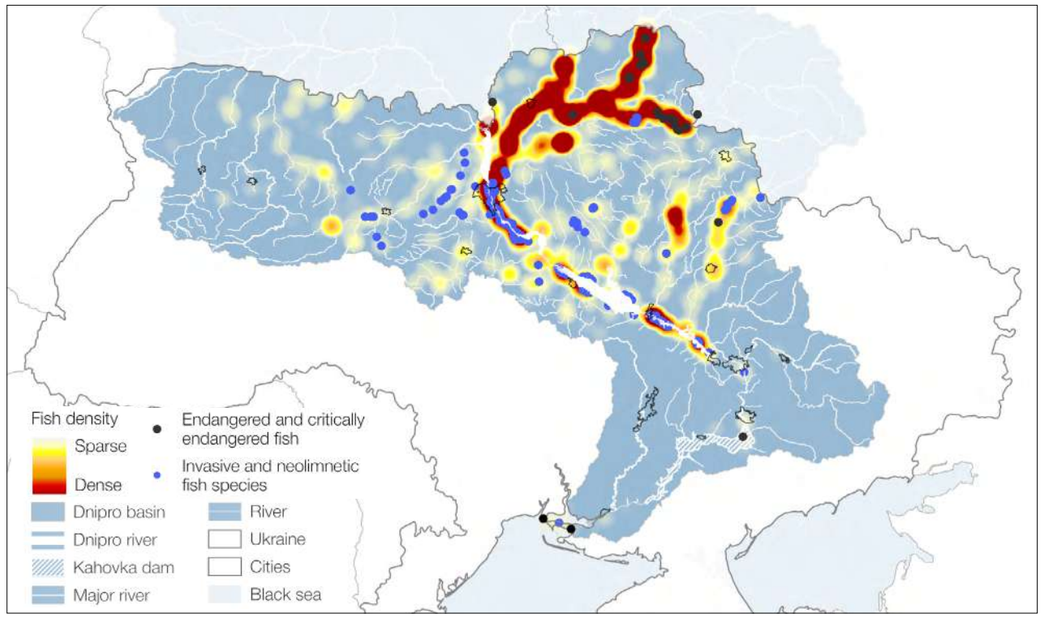


Figure 18. Density heatmap of fish species in the Dnipro River basin.
Author: Elaborated by Ro3kvit and Greenpeace CEE

iv. Main findings

- The Dnipro River Basin has a unique richness of biodiversity as there are 8,114 unique animal species; for comparison, the Danube River Basin has around 5,000 animal species;
- There are 524 unique species of protected and rare animals, including seven critically endangered species and five endangered species;
- Within a 10 km buffer from the Dnipro River, 5052 species (62%) of all animals and 270 protected or rare species (51%) of all protected or rare animals were recorded. This highlights the great importance of the river itself for the biodiversity within its basin;
- There are 93 unique species of mammals in the Dnipro River basin , which makes up 83% of all mammals in the country. Two critically endangered mammal species are recorded - Russian desman and the European hamster;
- 362 (80%) of all species of birds in Ukraine had been recorded within the Dnipro River basin; there are records of three endangered species included in the IUCN Red List of Threatened Species - Saker falcon, Great bustard and Egyptian vulture (IUCN, 2023);
- 106 different species of fish are registered within the Dnipro River basin, including records of one endangered species (Sterlet) and four critically endangered - Starry sturgeon, Russian sturgeon, European eel and Beluga; there are 46 recorded species of invasive fish within the Dnipro River basin, most of them located along the river in the areas between Kyiv and Dnipro city;
- 63 invasive species of animals (excluding alien fish) have been recorded, predominantly these species are Insects (26), Gastropods(15), Mammals(6) and Squamats (5);
- Concentration of all animal species is much higher in the northern part of the river basin, which could be because (1) the much higher density of rivers in the north, (2) the predominant forest and steppe-forest landscape in the northern part compared to the steppe, steppe-semi arid and steppe-arid mainly agricultural lands in the south; (3) lower number of records due to the war. This statement is more or less valid also for the Kyiv area, where the highest number of records could be due to the most significant concentration of people observing nature, as well as the largest number of educational and administrative institutions;
- Almost all datasets are from 2021, 2022, and 2023, which means that the analyzed data is quite actual. However, because of the challenges linked to the war, it should be revised and updated as soon as the war ends to provide a more accurate picture of the current situation of animal diversity within the Dnipro River basin.

2.1.6. Fungi

The dataset used for analyzing the Fungi kingdom combines data gathered mainly from academic entities, NGOs, and crowdsourcing platforms. In total, there are 27 490 records, which represent 1 864 fungi species in 27 different classes. Almost 85% of all records belong to two classes: Lecanoromycetes (Lichenized fungi, 13 363 records) and Agaricomycetes (Mushroom-forming fungi, 10276 records). The most commonly recorded fungi species are Maritime sunburst lichen and Shield lichen, as well as other lichen-forming fungi. Most of the hotspots of fungi species are located along the Dnipro River, with the highest concentration in the Kyiv area and the Kherson region, where the concentration is also dispersed towards the Black Sea and Kryvyi Rih.

i. Rare and protected fungi

Information about protected and rare fungi is combined from three datasets which incorporate relevant data. Two of the datasets are about protected fungi species listed in Resolution 6 and 4 of the Bern Convention and the Red Data Book of Ukraine and the other is about findings of rare fungi species. In total , there are 38 species of fungi with special status, 19 of which are protected and 19 are classified as rare. Most observed species are Xanthoparmelia camtschadalis (Kamchatka rock-shield lichen), Morchella steppicola (Morel of the steppes), Usnea hirta, Chaenotheca trichialis, Scytinium schraderi and Xanthoparmelia pokornyi.

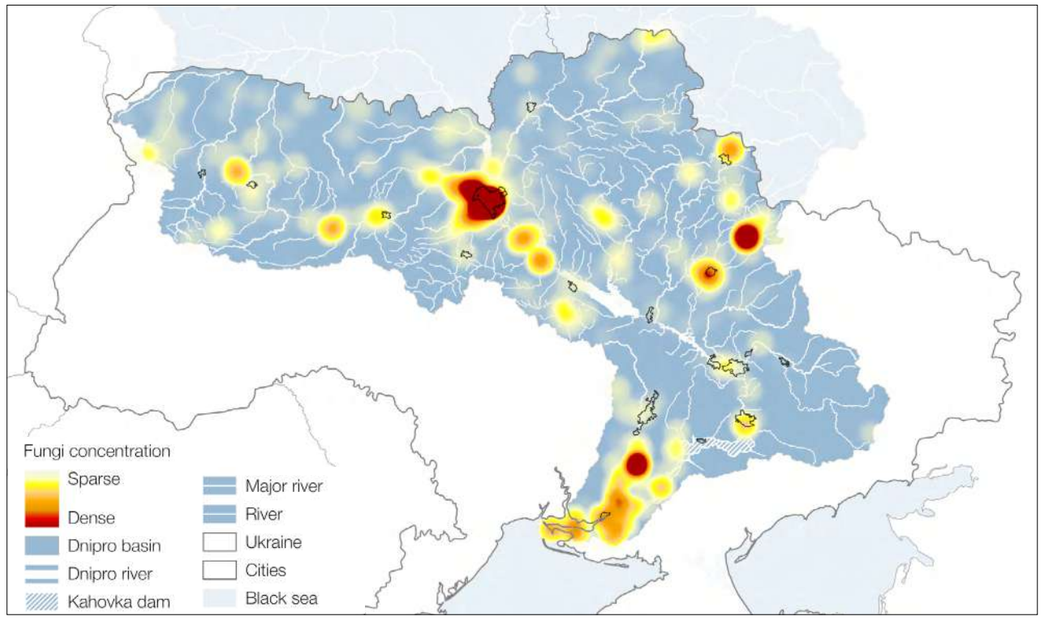


Figure 19. Density heatmap of fungi species in the Dnipro River basin.
Author: Elaborated by Ro3kvit and Greenpeace CEE

There are two close to each other hotspots with high concentrations of either protected or rare species - the one is the area between Kryvyi Rih and Kherson along Inhulets river and the other is the area of Dnipro delta and Dnipro-Bug estuary. On the upper part of Kremenchuk reservoir there is also an area with high concentration of protected and rare fungi. The other several hotspots are located in the periphery of Dnipro river basin.

ii. Main findings

There are recorded 1,864 fungi species, part of 27 different classes within the Dnipro River basin. Almost 85% of all records belong to two classes - Lecanoromycetes (Lichenized fungi) and Agaricomycetes (Mushroom-forming fungi); Most of the hotspots of fungi species are located along the Dnipro River, with the highest concentration in the Kyiv area and Kherson region, where the concentration is also dispersed towards the Black Sea and Kryvyi Rih;

There are 38 species of fungi with special status, 19 of which are protected, and 19 are classified as rare; The highest concentration of protected and rare fungi species is in two very close hotspots: the Kherson region along the Inhulets River, the Dnipro delta, and the Dnipro-Bug estuary.

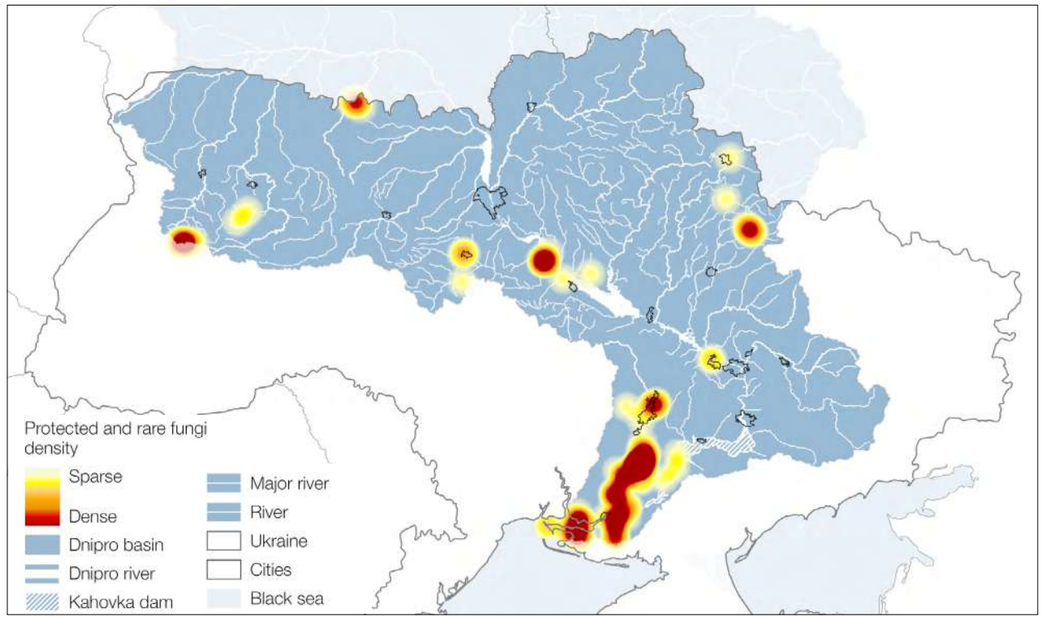


Figure 20. Density heatmap of rare and protected fungi species in the Dnipro River basin.
Author: Elaborated by Ro3kvit and Greenpeace CEE

2.2. Water supply

2.2.1. Water Usage: Overview

Water constitutes life in itself, and it creates life for the natural environment we live in. But water is also a vital resource. Humans use it for various purposes, from sanitation and hygiene to agriculture and food production, industrial activity, energy production, transportation and more. Water is, without overestimation, an essential good whose quantity and quality define the health of the population and of a country. Many of us, however, often tend to take water for granted. It flows from the tap directly into our bathtubs and into our glasses. But have you ever wondered how it reaches you and where it comes from?

In Ukraine, as much as 59% of total water usage comes from the Dnipro River, accounting for 6,524 million cubic meters per year (data for 2019) (DRBMP, 2023, p.77). To serve the various human needs, a complex system of water management functions, including various facilities like hydraulic structures, channels for water transfer (from water-rich to water-scarce areas), hydro-amelioration systems, large and small reservoirs as well as research, education and management institutions that design, operate and maintain these facilities (Dniprocratia, 2023).

The largest source of water intake falls on the cascade of water reservoirs, which provides up to 80% of the total water intake from the Dnipro River basin (EUWI+, 2019). The distribution of water intake by sub-basins also shows that the vast majority (64%) of water is collected from the Lower Dnipro sub-basin, followed by the Middle Dnipro sub-basin (27%), and lastly, the Upper Dnipro, Desna and Prypiat sub-basins in the north amounting together to the other 9% of water intake (DRBMP, 2023).

In 2017, irreversible water consumption from natural water bodies in the Dnipro River Basin amounted to 2,830 million cubic meters. Meanwhile, another 2,918 million cubic meters were discharged back into the Dnipro River and its tributaries (EUWi+, 2019). The structure of water usage by sector, as outlined in the most recent report by Ukraine's Water Agency (DRBMP, 2023), looked as follows:

Residential (municipal)	16.8% (1097 mcm)
Agriculture	38.5% (2515 mcm)
Industry	44.3% (2891 mcm)
Transportation and other	< 1% (20 mcm)

2.2.2. Water usage by the municipal sector

Based on the assessment of its socio-economic significance, the municipal sector is entirely dependent on water resources. It is also the most water-intensive sector of the economy, with low discharge levels and a high dependency on the quality of the water. In other words, the municipal sector heavily relies on clean freshwater resources and releases relatively little water back into the environment.

In 2019, municipal water users have withdrawn 1,097 million cubic meters of water amounting to 16.8% of the total water withdrawn from the Dnipro River Basin (DRBMP, 2023, p.79).

Municipal water usage in the Dnipro basin involves meeting the drinking and household needs of the population, which is highly concentrated (74%) in large urban areas. Providing that over 20 million people out of the total population of Ukraine reside directly within the boundaries of the Dnipro River Basin, millions of households depend on its waters (EUWI+, 2020, p.22). Major cities include Ukraine's capital Kyiv, as well as Dnipro, Zaporizhzhia, Kherson, Kryvyi Rih, Chernihiv, Rivne, Zhytomyr, Lutsk, and others.

According to the technical report by EUWI+ (2020), 1,291 communal enterprises in the Dnipro River Basin extract water from the surface and underground water objects for subsequent use for drinking and utility purposes.

The most significant municipal water users in the residential and municipal sector are the' Vodokanals' of the major cities along the river — enterprises in charge of providing water supply and wastewater services to the urban and rural populations. These include the "Kyivvodokanal", "Dniprovodokanal", "Aulskyvodovid", "Miskvodokanal" in Kamianske, the "VUVKG of Kherson city", "Vodokanal" in Zaporizhzhia City, "Kryvbassvodokanal" in Kryvyi Rih, "Nikopolske VUVKG" in Nikopol, "Chernihivvodokanal", "Pavlogradske VUVGK" in Pavlograd and others.

In total, the registry includes 316 municipal wastewater treatment plants (MWWTPs). Of these, 177 MWWTPs received discharges from enterprises for further purification in 2017. In total, 302,342 million cubic meters of sewage were cleared by the enterprises mentioned above. The MWWTPs in the Dnipro basin serve 11,731,005 people (EUWI+, 2020, p.23-24).

2.3. Agriculture and fishing

2.3.1. Agriculture in Ukraine: Overview

The water from the Dnipro is a critical resource for Ukrainian agriculture. Often dubbed “the breadbasket” (be it of Europe, Russia or other parts of the world), Ukraine’s agricultural capacity is indeed significant, not only at the regional scale, but globally. Over a quarter of the world’s chernozem — some of the most fertile land on earth — is within Ukraine’s borders.

Ranked third after Bangladesh and Denmark, Ukraine’s share of arable land in respect to its overall area constitutes 56.8%, which is vastly greater than the world average (10.8%) or the the EU average (24.5%) (World Bank, 2021). In 2019, as much as 28 million hectares out of Ukraine’s total area of 60 million hectares was cultivated land, which accounts to 46.7% (OSW, 2021)

It is not surprising, therefore, that the agriculture constitutes one of the largest sectors in the Ukrainian economy. In 2021, approximately 14% of the country’s population was employed in agricultural production, accounting for 10.9% of the country’s GDP (Vox Ukraine, 2023). Agricultural activity and production is rather evenly distributed between the regions of the Dnipro River Basin, with the Vinnytsia region, leading the race.

Ukraine has a developed food complex capable of not only fully providing the country’s population with food products but also forming an active position for the country in the international markets of a range of key agricultural products, including grains and oilseeds (NISS, 2024). Its traditionally strong food exports make it an important guarantor of food security in the world.

Prior to russia’s full-scale invasion, Ukraine was among the top five largest grain exporters in the world, exporting roughly three-quarters of its production, with domestic grain consumption accounting for only 20-25%. Ukraine supplied 10% of the world’s wheat and rapeseed exports, 14% of corn and barley, and over 47% of sunflower oil (Vox Ukraine, 2023; NISS, 2024).

The cultivation of cereals and oilseeds is only slightly diversified with three species – maize, wheat and barley – accounting for the vast majority of cereals (97% of production in total); similarly: sunflower, rapeseed and soya account for 99% of all oilseed production. (OSW, 2021).

In total, agricultural products amounted to 41% of the country’s overall exports, making agriculture one of the major sectors of Ukraine’s economy.

Figure 1. A photo of agricultural fields in the Mykoliv region, 2021
Author: Oleksa 15; Source: Wikipedia.org (CC BY-SA 4.0)

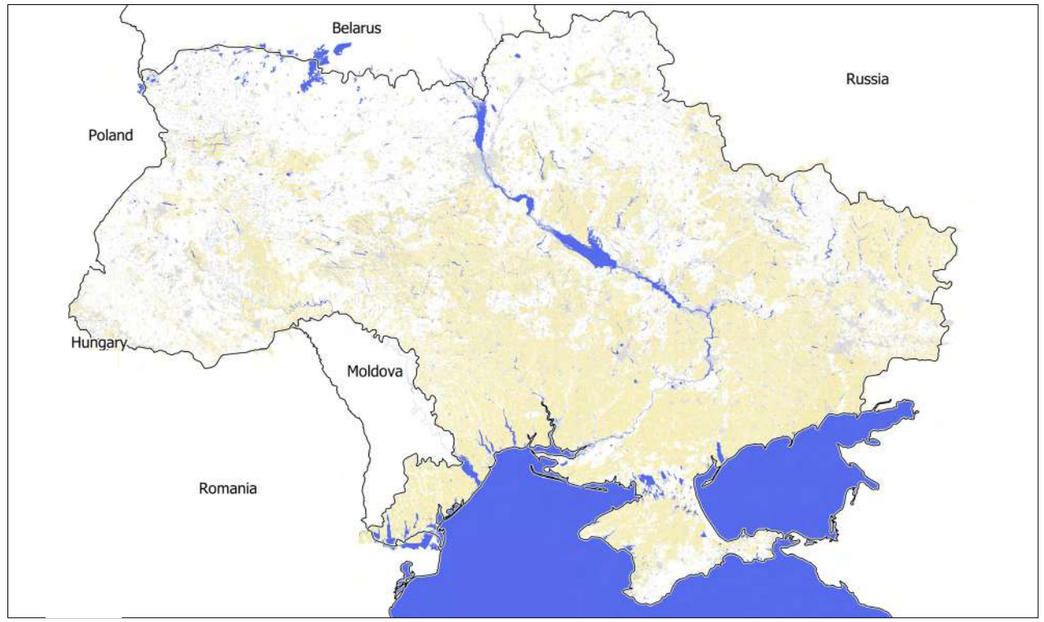


Figure 2. A map of Ukraine’s agricultural land, marked in light yellow colour
Author: Elaborated by Ro3kvit and Greenpeace CEE

2.3.2. Water supply for agriculture

Given the scale of production and land involved in Ukraine's agricultural sector, the amount of water required for agrarian needs is accordingly very significant. As the main water body flowing through Ukraine from north to south, the Dnipro River Basin is, among other things, a main source of water for agricultural needs. The percentage of arable land within the limits of the Dnipro River Basin significantly exceeds the already high national data, amounting to as much as 69% of the land surface.

In terms of water usage, around 38.5% of the total water volume in the Dnipro River Basin, or 2,515 million cubic meters, are withdrawn for the purposes of agricultural production; 97% of these, equivalent to 2,446.6 million cubic meters of water, are drawn from surface water bodies of the Dnipro River Basin, and only 3% from groundwaters (68.4 million cubic meters) (DRBMP, 2023). Most of the water withdrawal occurs in Ukraine's more arid southern regions, towards the Lower Dnipro. Namely, the agricultural sector's primary water users are producers from the Kherson, Zaporizhzhia and Mykolaiv regions. The water withdrawal structure for agriculture is dominated by irrigation needs, accounting for 86%. According to the World Bank Group and the Ukrainian State Agency of Water Resources, irrigation covers only about 1% of all agricultural land; however, it is particularly significant for certain types of crops (World Bank, 2017).

Almost all tomatoes and rice production and 15% of potatoes, which are concentrated in the southern regions of Ukraine, depend on irrigation. As much as 309,000 hectares or 14% of farmland depends on irrigation in the Kherson region, followed by 50,400 hectares in the Zaporizhzhia region and another 29,400 in the Dnipro region (LSEG, 2023). Among the cultures produced in the Kherson region are watermelons, tomatoes, cherries, apricots, peaches, apples, plums, and vast quantities of sunflower seeds, mainly destined for global markets. The Ukrainian irrigation systems generally function with multi-level pump stations and networks of canals, a legacy left by the Soviet Union. The largest and most famous examples include the Dnipro-Kryvyi Rih Canal, the Kakhovka Main Canal, and the North Crimean Canal, all supplying Dnipro River water from the Kakhovka reservoir to the southern regions of Ukraine. Built in the Soviet era in the 1960s and 1970s, they were constructed with the aim to increase both the agricultural and industrial viability of the regions. The importance of such large-scale infrastructural facilities was particularly underlined in 2014 when Ukraine closed the valves of the North-Crimean Canal in response to Russia's illegal military occupation of the Crimean peninsula. Over 70% of the water supplied from the Dnipro River to Crimea was used by the agricultural sector. Overall, the canal supplied up to 85% of Crimea's total freshwater use (Suspilne, 2021).

The Dnipro River plays an essential role in providing water for Ukraine's agricultural production. The implications of these are twofold: not only is the Dnipro River central to Ukraine's economic activity and population well-being through domestic food production and a high rate of employment, the Dnipro River also plays a central role in global food security, providing that the majority of Ukraine's agricultural production (mainly grain and oilseeds) are exported to various countries and regions of the world. According to information by the FAO, the IMF, and other international organisations, supplies from Ukraine are particularly important for the Least Developed Countries (LDC) and those which fall into Low-Income Food-Deficit Country (LIFDC) groups that import large amounts of food (Parliament UK, 2022). Among others, these include many African nations, including Algeria, Egypt, Libya, Morocco, Tunisia, Nigeria, Ethiopia, Sudan and South Africa, which account for 80 per cent of wheat imports.

Figures 3 and 4. Satelite images of the irrigation canals and agricultural fields on the left bank of Dnipro River in the Kherson region of Ukraine. The top image shows two major irrigation canals: the Kakhovka canal (right) and the Crimean canal (left), which transported water from the Dnipro River inland for agricultural and other needs. Source: Google Earth (2024).

2.3.3. Industrial fishing: Historical context

Another important industry that accounts for 10% of the agricultural sector's total water withdrawal from the Dnipro River Basin is industrial fishing, more precisely — fisheries involved in the cultivation of aquatic resources such as fingerlings, fry, and juveniles of commercial fish (DRBMP, 2023). Generally, the fishing industry in Ukraine — and the Dnipro River Basin is not an exception — has been on the decline throughout the years of Ukraine's independence and, therefore, now plays a minor role both in terms of water needs and economic activity. However, as it relates directly to the Dnipro River, it nonetheless plays a fair part in the river ecosystem and the socio-economic context.

As mentioned several times above, the fish population in the Dnipro River, as observed and recorded historically, has been both diverse and abundant. Fish has been, among others, a food source for the people who lived on the banks of the river and its tributaries. It was also an essential commodity for trade in ancient times and early modern times. For instance, fishing was one of the most widespread types of industrial activity among the Zaporozhians and other groups of the Ukrainian population in the second half of the 17th and 18th centuries. The famous Ukrainian historian and ethnographer Dmytro Yavornytsky noted that during the period of the Old and Oleshkiv Sich (1652-1734), the Cossacks were fed, clothed, shod, and armed through fishing (State Agency of Water Resources of Ukraine, 2020).

At the time, fishing targeted utterly different types of fish than today, including sterlet, sturgeon, beluga, mullet, and grayling. In just two months in 1771, 4,380 delicacies of sterlet were caught by the garth as gifts to the Zaporizhian leadership (State Agency of Water Resources of Ukraine, 2020).

The industrial catching of catfish, carp, bream, pike, zander, tench, perch, roach, bleak, and rudd also had an industrial significance. In the 19th century, during the russian imperial rule, fishing started to develop on a more industrial scale in the Dnipro River.

Throughout the Soviet period, the construction of the cascade of reservoirs for the hydroelectric power stations on the Dnipro River significantly impacted the natural ecosystem and their fish populations by restricting free access to migratory fish upstream. The number of native fish species decreased due to the pollution, siltation, loss of rheophilic conditions, spawning grounds, and inability to go upstream. In addition, as noted by UNCG (2023), "the 'blooming' of the water, the deterioration of the oxygen regime led to the disappearance or reduction of fish sensitive to the oxygen content in the water, and the presence of low-value species that can tolerate brackish water and withstand high turbidity of the water increased".

To compensate for the losses of large volumes of native species – including sturgeon and predatory fish – low-value adventive fish species were artificially cultivated (UNCG, 2023). New fisheries were organised in large reservoirs, different from riverine fisheries, with the main commercial fish species including bream, zander, carp, tench, pike, catfish and perch. Several farms have been established on the reservoirs to cultivate fingerlings of valuable fish species for stocking rivers and reservoirs. For instance, in 1969, 172,600 tons of fish were harvested from the Dnipro reservoirs (with a surface area of 5,282 km^2), about 33 kg per hectare. The highest fish productivity (about 40 kg) was observed in the two largest reservoirs: the Kakhovka and Kremenchuk reservoirs.

2.3.4. Ukraine's fishing industry in the present times

Today, the fishing industry is crucial to Ukraine's domestic food market, with 80 per cent of the annual catch coming from the Dnipro and its reservoirs, according to the Ukrainian Nature Conservation Group (NYTimes, 2023). While at the Dnipro Estuary, 66 sorts of fish are recorded, the waters of the Dnipro reservoirs have a slightly lower diversity at 43 fish species recorded before Russia's full-scale invasion. The Kakhovka reservoir had one of the largest concentrations of freshwater commercially important fish species in Ukraine, with no less than 20 different species and annual catches amounting to up to 2.6 thousand tons (UNCG, 2023).

An important component for the development of the fishing industry and, thus, one of the main priorities of Ukraine's State Fisheries Agency is fish stocking. In the context of deteriorating conditions for the natural migration and spawning of fish, a large part of the total industrial fish production is formed due to artificial reproduction.

Given the increased anthropogenic pressures, artificial reproduction contributes significantly to replenishing natural populations of indigenous and valuable fish species, playing both an essential ecological role by maintaining sustainable fish stocks in water bodies and a crucial economic role by restoring the fishery potential (State Agency of Fisheries of Ukraine, 2018).

The stocking of water bodies in Ukraine is carried out by users, public organizations, and enterprises operating under the Regimes of Water Use, as well as through compensatory funds and charitable contributions. However, the most extensive stocking of aquatic biota is carried out at the expense of the state budget by four state fish reproduction complexes, namely: Novokakhovka sturgeon fish breeding plant, Kherson experimental plant for breeding juvenile sturgeon, Experimental Dnipro sturgeon fish breeding plant and Trout fish breeding plant "Lopushno".

2.4. Industry

2.4.1. Ukraine's Industrial sector: General context

For hundreds of years, the Dnipro has delivered life to Ukraine's industrial heart, helping to keep economies working and production growing (WP, 2024). Today, the industrial sector continues to play a vital role in Ukraine's economy, and its performance indicators are a crucial factor in socio-economic development.

Before the 2008 Global Financial crisis, the industrial sector employed up to 18% of the country's population and produced around 27% of the country's GDP. Although the share of the industrial sector in Ukraine's GDP has decreased over the long term, reducing to 21% in 2013 even before the challenges faced by the russian illegal invasion of Crimea and the war in the Eastern regions of Donetsk and Luhansk, the country still remains an essential industrial producer in international comparisons (IER, 2014).

Despite representing around one-fifth of the country's production, the industrial sector accounted for up to 70% of Ukraine's exports, equivalent to UAH487 billion ($60 billion) in the same year, making it by far the most important export sector of the economy.

The industrial structure is composed of various activities, including ferrous and non-ferrous metallurgy, chemical and petrochemical and gas, machine building and metal-working, fuel and power generation (discussed separately in 2.5. Energy), forest, wood-working and wood pulp and paper, construction materials, light industries, food industries and others. The highest share of industrial output is generated by ferrous metallurgy, the chemical industry and the food industry.

The foundation of the Ukrainian industry is the capital accumulated during the Soviet era, acquired by private owners in independent Ukraine during the period of mass privatization. The highest spatial concentration of industry is observed in industrially developed regions, predominating heavy industry enterprises (Donetsk, Dnipro, Luhansk, Zaporizhzhia). Additionally, significant industrial activity is territorially concentrated in Ukraine's major urban centres and their surrounding regions: Kyiv, Kharkiv, Odesa, and Lviv. The ground in these parts of Ukraine is a source of many profitable materials. These materials are raw, and workers are used to their often hard work. The scale of mines and factories is large, and the mining and production demand a lot of other resources, like energy and water.

2.4.2. Industrial activity in the Dnipro River Basin: Overview

In the Dnipro River basin, industrial activity is developed, with the main branches being energy production, mining and the extraction of minerals (mainly coal), metallurgy, chemical and petrochemical industry, pharmaceuticals, glass production, textiles, pulp and paper industry, animal husbandry, and food production (DRB-MP, 2023, p.40). In total, the territory of the basin accounts for 6,173 enterprises, of which 1,291 are communal utilities (EUWI+, 2019, p.23-24). The industrial sector accounts for most water intake from the Dnipro River basin, with 2891 million cubic meters, equivalent to 44.3% of the total water withdrawn. The needs of industrial water users are mainly met from surface water bodies (92% or 2658.46 million cubic meters), while the other 8% (232.6 million cubic meters) are taken from groundwater sources. The largest watershed for the power industry is carried out within the Zaporizhzhia, the Kyiv, and the Dnipropetrovsk Oblasts. Among all industries, the energy sector uses the largest volume of water and coupled with its particular significance and importance, we believe it deserves to be discussed separately (see 2.5. Energy). Before that, it is important to get a general understanding of the scope and scale of industries that operate in the Dnipro River Basin and that depend on water from the Dnipro River.

Figure 5: A photo of the city of Zaporizhzhia, viewed from a drone. Large industrial facilities are seen on the background
Author: Oleksandr Malyon

2.4.3. Mining industry

In the Dnipro River basin, the extraction of minerals is a significant industrial activity. Major stakeholders include both state-owned and private companies. The state has a substantial interest in preserving and developing the extraction sector to ensure the country's energy security. At the same time, private companies engage in extraction for commercial purposes. Major industrial corporations engaged in extraction include DTEK, Metinvest Holding, "Marganets GOK," and others. DTEK, a part of the DTEK group, is one of the largest extraction enterprises in Ukraine.

It primarily operates in the Donetsk and Luhansk regions, with some operations also in the Dnipropetrovsk region (DTEK, 2020). The Ingulets Mining and Processing Plant, the Novokryvorizky Mining and Processing Plant, the Southern Mining and Processing Plant, the Northern Mining and Processing Plant, the Central Mining and Processing Plant, and the Sukha Balka mine are located in the Kryvyi Rih basin within the Dnipro River basin.

Most mineral extraction in the Dnipro River basin occurs inland, particularly in the coal-rich regions of eastern Ukraine. However, for increased efficiency, some enterprises are located along riverbanks to facilitate the transportation of extracted materials. One example is the Marganets Mining and Processing Plant, which is located in the city of Marganets in the Dnipropetrovsk region and is the only enterprise in Ukraine that extracts manganese ore through both underground and open-pit methods (MGOK, no date).

The most notable example is the Poltava Mining and Processing Plant Quarry, located in Horishni Plavni, a town situated by the Dnipro River. The plant is operated by Ferrexpo AG, part of FTSE 250. It is the largest Ukrainian exporter of iron ore pellets to Europe. With almost half a kilometre deep and over 7 kilometres long, it is the largest quarry in Europe, making it also a trendy destination for industrial tourism, as visitors come to see the gigantic hole and the machinery that operates here.

Figure 6: Satellite view of the open pit quarry (left) in Horishni Plavni (Poltava region) and the Dnipro River (right)
Source: Google Earth (Accessed: May 2024)

Figure 7. Photo of the quarry of the Poltava Mining and Processing Plant in Horishni Plavni (Poltava region)
Author/Source: Kar'yeri Ukrainy-NADRA.info. (https://www.facebook.com/ukrquarries), 2020.

2.4.4. Metallurgical industry

The metallurgical industry plays a crucial role in Ukraine's steel and metal production. Private companies are the main stakeholders in the metallurgical industry. Major corporations operating in this sector include Metinvest, ArcelorMittal, Interpipe. Among Ukrainian companies, Metinvest, and among international players, ArcelorMittal, have commercial interests in producing and exporting metal products. Metallurgical plants are typically located inland, closer to sources of iron ore and other raw materials. This positioning helps reduce transportation costs for raw materials and finished products.

Metinvest is one of the largest metallurgical companies in Ukraine and is concentrated in the Donetsk, Zaporizhzhia, and Dnipropetrovsk regions, including the Dnipro River basin. In Zaporizhzhia, notable enterprises include Zaporizhstal, Zaporizhkoks, and Promservis. Zaporizhstal is a Ukrainian metallurgical plant in Zaporizhzhia, one of the city's major industrial enterprises. It is one of Europe's largest metallurgical plants and is part of the Metinvest group (since 2011). The plant is one of Ukraine's largest environmental polluters. It is located in the Zavodsky district of Zaporizhzhia, employing approximately 10,435 people. ArcelorMittal Kryvyi Rih is part of the global ArcelorMittal group and is located in the Kryvyi Rih basin of the Dnipro River. Interpipe specialises in pipe production, while the Dnipro Metallurgical Plant focuses on steel production.

2.4.5. Chemical and petrochemical industries

In the Dnipro River basin, the chemical and petrochemical industries are represented by corporations such as Ukrnafta, LITTA Group, Rivneazot, Galchimia and others. Stakeholders in this industry can include both state-owned and private companies. The state has an interest in ensuring national security in the chemical and petrochemical production sectors. At the same time, private companies aim to profit from commercial activities. Most chemical and petrochemical enterprises are typically located inland, closer to raw material sources or transportation hubs for supplying products to domestic and international markets.

Ukrnafta is one of the largest oil extraction enterprises in Ukraine, primarily concentrated in the Carpathian region in the west of the country, distant from the Dnipro River basin, but it includes the Kremenchuk Refinery (UNXP, no date). LITTA Group specializes in chemical production and has facilities in Kyiv and other regions of Ukraine. Rivneazot and Galchimia produce mineral fertilizers and chemical substances, particularly nitrogen compounds (OSTCHEM, no date).

Figure 8: Satellite view of industrial sites on the banks of the Dnipro River in Kamianske (Dnipropetrovsk region).
Source: Google Earth (Accessed: May 2024)

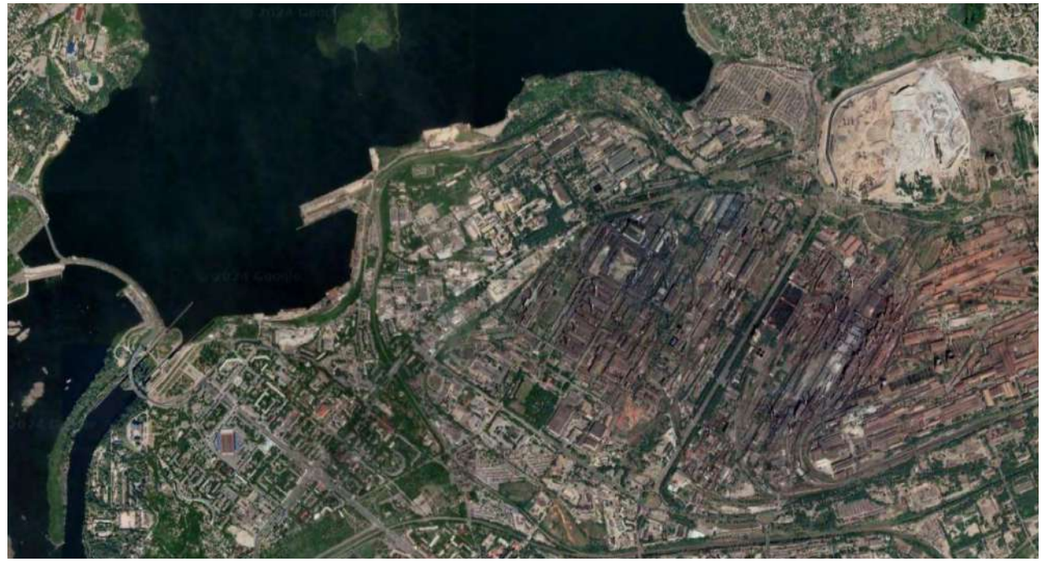


Figure 9: Satellite view of industrial sites near the banks of the Dnipro River in Zaporizhzhia.
Source: Google Earth (Accessed: May 2024)

2.4.6. Food industry

In the Dnipro River basin, animal husbandry and food processing are important industries represented by companies such as Mironivsky Hliboproduct (MHP), Vinnytsia Poultry Farm, Dnipro Meat Processing Plant and others. Most animal husbandry and food processing enterprises are located along riverbanks or near them due to the need for water for irrigation, feeding, and production purposes. The state supports the development of the food industry to ensure food security for the nation. At the same time, private companies engage in commercial activities. Stakeholders in this industry include both state-owned and private companies.

Public Joint Stock Company "Mironivsky Hliboproduct" (MHP) is an agro-industrial holding and a prominent domestic leader with 20 organisations operating in seven Ukrainian regions. Apart from poultry farming, MHP is engaged in agricultural crop cultivation, one of the company's key business segments. MHP's land bank comprises 370,000 hectares of land, and the enterprise aims to achieve a leading position in Europe, surpassing a capitalisation threshold of five million. MHP's shares are listed on the London Stock Exchange. The central office is located in Kyiv, and the company owns elevators for grain and oilseed storage and procurement at competitive regional prices. The company employs over 12,000 workers in the Dnipro River basin.

Vinnytsia Poultry Farm specialises in poultry farming and is located in the Vinnytsia region. MHP is the largest producer and exporter of chicken in Ukraine. The company focuses on chicken production, grain cultivation, and other agricultural activities, including processed meat products and ready-to-eat foods. The Dnipro Meat Processing Plant (part of the KSG Agro group since 2011) produces meat products and is located in the Dnipropetrovsk region. The plant's capacity is 400 tons of sausage products and 30 tons of smoked sausages per month. Dnipro Meat Processing Plant produces over 100 varieties of sausage products, including boiled, semi-smoked, smoked, and delicatessen meats.

2.4.7. River sand extraction

Another industry, very specific to and dependent on the Dnipro River, is the extraction of sand — the so-called 'gold of the construction industry'. With a growing construction industry over the last few decades, sand has been used for various purposes, from concrete production to road repair and construction. While Ukraine extracts sand from open-pit mining, river sand is also an important source to meet the demand of urban development (Texty, 2019).

The largest operator of river sand in Ukraine is Ukrrichflot. The company owns three sand deposits with a total volume of 249 million tons, estimated to represent approximately 12% of the officially explored reserves of river sand in Ukraine) (URF, no date). The other two major companies involved in river sand extraction are Kovalska and Nikstrom, which have controlled deposit areas of 1,582 and 1,066 hectares, respectively, compared to the 1,873 hectares for Ukrrichflot.

The construction industry already employs a significant percentage of the population, but the likely long-term need for infrastructure reconstruction all around Ukraine due to the damages inflicted by Russia's invasion will likely only increase the demand for sand.

Figure 10: Photo of sand extracted from the Dnipro River stored on the banks of the Dnipro River
Author: unknown; Source: Ukrrichflot

2.5. Energy

2.5.1. The water and energy nexus

According to the state water use monitoring data, within the industrial sector, the energy sector accounts for 79% of all water from the Dnipro River Basin, amounting to 2,284 mcm, making it the second largest water user by sector after agriculture (DRBMP, 2023). Water and energy are two closely interdependent critical resources.

Energy supply depends on water. Water supply depends on energy.

Water is essential for almost every aspect of producing energy, from electricity generation to fossil fuel extraction to biofuel cultivation. According to the IEA, the energy sector accounts for roughly 10% of total global freshwater use. At the same time, maintaining global water supply is also dependent on energy, which is required to extract water from lakes, rivers and oceans, lift groundwater from aquifers and pump it through pipes and canals, treat water and deliver it to users. More broadly, both water and energy are foundational to economic development, food production, environmental sustainability and human well-being (IEA, 2016; IEA, 2024).

2.5.2. Ukraine's energy profile

With its considerable population and high energy consumption, Ukraine is one of the largest energy markets in Europe and the top energy consumer among EU4Energy focus countries (IEA, 2020). Ukraine's primary energy supply amounted to 92.1 million tons of oil equivalent (Mtoe) in 2021 (Naftogaz, 2021). In terms of total final consumption (TFC) of energy, as of 2021 the industrial sector held the largest share with 32%, followed by the residential sector (28%), transport (19%) and commercial and public services with (10%). This indicator includes all energy consumption by the end-user – fuels for heating, transport and industrial processes, electricity for households and businesses, etc.

Before the full-scale invasion, the largest energy sources in final consumption in Ukraine were natural gas at 27%, electricity at 21%, and oil products at 21%. The energy system was and still is heavily dependent on fossil fuels and nuclear power (IEA 2021). Ukraine's industry consumes nearly 658,000 TJ per year, with most of it being in the form of coal for combustion processes (30%) and electricity (26%). This high consumption is largely attributed to the country's highly developed metallurgy sector and significant reserves of low-cost, high-quality iron ore. Ukraine ranks fifth globally in terms of magnetite ore reserves (Ukraine Facility, 2024).

The residential sector consumed 567,000 TJ in 2021 and is the second largest contributor to the energy intensity of the Ukrainian economy. Natural gas constitutes the primary energy source for the residential sector, representing 46% of final consumption, followed by electricity at 24%.

Figure 1: Photo of DniproHES, Zaporizhzhia
Author: Oleksandr Malyon

Figure 2: Photo of DniproHES-2, Zaporizhzhia
Author: Oleksandr Malyon

Before the full-scale invasion, Ukraine's domestic energy production could cover as much as 65% of the total consumption through a combination of energy sources, including thermal, combined heat, nuclear, hydro, and various renewable sources of power generation. Ukraine's energy mix is relatively diversified, with no fuel representing more than 30% of the energy mix. In 2018, the share of coal (the country's primary fuel) dropped to 30%, followed closely by natural gas (28%) and nuclear (24%) (IEA, 2020). Ukraine has abundant mineral resources, including crude oil, coal, and natural gas, but in quantities that are insufficient to meet total energy demand. Its high self-sufficiency is largely explained by nuclear energy production, which covers over half of the country's total demand, making Ukraine the world's seventh-highest producer of nuclear energy.

In December 2005, Ukraine and the EU signed an energy cooperation agreement that links the country more strongly to Western Europe in respect to both nuclear energy and electricity supply. Ukraine has investigated developing its significant shale gas deposits, but domestic production remains modest (World Nuclear Association, 2024). In terms of electricity generation, Ukraine also relies mostly on nuclear power, followed by coal. The share of renewable sources in the energy mix is also growing, reaching just below 6.5% in 2021, according to the IEA (Naftogaz, 2021). In 2021, the electricity produced in the country is close to 158 TWh (IEA, 2023). Its distribution by sources is as follows:

Nuclear	54.59% (86.2TWh)
Coal	23.14% (36.5 TWh)
Gas	9.08% (14.3TWh)
Hydro	6.54% (10.3 TWh)
Solar (PV)	4.16% (6.6 TWh)
Wind	1.79% (2.8 TWh)
Biofuels	0.48% (0.7 TWh)
Oil	0.13% (0.2 TWh)
Others	0.09% (0.1 TWh)

Within this wider national energy context, the role of the Dnipro River has been central. In addition to the 6 hydroelectric power stations situated directly on the Dnipro River, four of the five nuclear plants, three CHP power plants and four thermal power stations are situated within the Dnipro River Basin, often being directly linked to if not relying on the river's water. The sections below give a more detailed overview of the various sources of energy in Ukraine in relation to the Dnipro River and its basin.

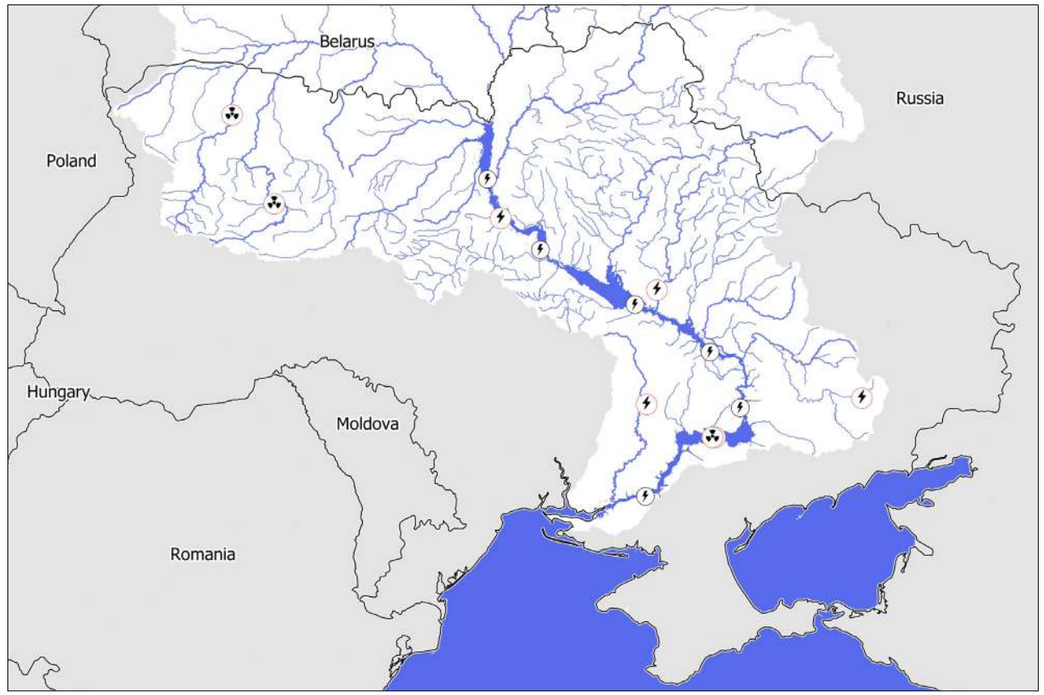


Figure 3: Map of major energy power plants in the Dnipro River basin, including Hydro, Thermal and Nuclear powerplans
Author: Elaborated by Ro3kvit and Greepeace CEE

2.5.3. Hydroelectric power

Harnessing the kinetic energy of flowing water, hydropower has long illuminated homes and powered industries. While far behind nuclear or thermal power in terms of energy capacity and production in Ukraine, hydropower undoubtedly deserves particular attention when it comes to the Dnipro River. Ukraine's large dams stand as testaments to engineering prowess. Their massive reservoirs store vast volumes of water, releasing it through turbines to generate electricity with undeniable advantages: reliable power, long lifespan and use beyond power utility. Unlike weather-dependent renewables like solar or wind, dams offer predictable, dispatchable power, acting as a backbone for grid stability and baseload generation. With proper maintenance, these giants can churn out electricity for centuries, ensuring energy security for generations.

In Ukraine, throughout the Soviet period, from the North near the border with Belarus and to the South near Kakhovka, the Dnipro River was essentially transformed into a cascade of water reservoirs providing for the functioning of a series of six hydroelectric power stations (see 1.2. Historical Overview). Constructed between 1932 and 1975, Ukraine's hydroelectric power plants are owned by the state company Ukrhydroenergo and continue to provide reliable energy. Before the russian terrorist destruction of the Kakhovka dam on June 6, 2023, and the missile attack on the DniproHES on March 22, 2024, the total capacity of all Dnipro hydroelectric power stations amounted altogether to just below 3800 megawatts (MW). The Dnipro HPP has the greatest capacity of 1570 MW, while the Kakhovka HPP had the smallest capacity at 350 MW. The average yearly generation of primary electricity by the cascade of hydroelectric stations constituted around 10,000 GWh.

As of 2018, aside from the major HES on the Dnipro River, another 46 small hydroelectric power plants operated in the Dnipro River basin, with a total capacity of about 18 MW. Of those, 72%, accounting for 83% of the total capacity, are concentrated in the right-bank part of the basin on the Dnipro River tributaries. The largest number of small HPPs operate on the Sluch River (Pripyat Sub-basin) and the Ros River on the right bank and on the Psel River on the left bank. Among the regions within the Dnipro River basin, the largest number of small HPPs (18 units) are operating in the Zhytomyr region, followed by the Khmelnytska region (8 units) and five units on the border of the Kyiv and Poltava regions. By installed capacity, Cherkasy is leading the race with 4.7 MW, followed by the Zhytomyr region (4.3 MW) and the Kyiv region (2.5 MW). The vast majority of small HPPs (75%) have a capacity of 100 to 500 kW, with only three plants exceeding 1,000 kW. In the average water year, small HPPs produce 70-75 GWh of electricity. (EUWI+, 2020, p.28-29).

While hydroelectric power accounted for a minor part of Ukraine's energy balance throughout post-1991 Ukraine, reaching about 6.7% in early 2022, the role of the dams is nonetheless important for the energy landscape. Not only does it play a significant role in the stability of the power system in Ukraine, providing high manoeuvring capacities for regulating daily load schedules, covering peak demand, and filling nighttime deficits, hydropower also serves as a reserve capacity in case of emergencies (Ukrhydroenergo, 2023). Since the invasion of Russia in 2014, the role of hydroelectric power has obtained a larger dimension in the context of a shift away from dependency on Russian fossil fuels and remains substantial to this day. In 2016, the government approved a programme for hydropower development aimed at increasing installed generation capacity by 3.3 GW and raising hydro's share in electricity generation to 15.5% by 2026 (IEA, 2020).

Figure 4: Photo of the DniproHES (Hydroelectric Station and dam) in Zaporizhzhia, drone view.
Author: unknown; Source: Ukrhydroenergo

Name	Location	Installed capacity (MW)	Construction year(s)
Kyiv HES	Vyshhorod, Kyiv region	408,4	1972-1975
Kyiv PSPS	Vyshhorod, Kyiv region	135-235,5	1963-1970
Kaniv HES	Kaniv, Cherkasy region	500	1964-1968
Kaniv PSPS	Kaniv, Cherkasy region	1000-1040	—
Kremenchuk HES	Svitlovodsk, Poltava region	700,4	1959-1960
Middle Dnipro HES	Kamianske, Dnipropetrovsk region	352	1963
Dnipro HES	Zaporizhzhia, Zaporizhzhia region	1569	1927-1932, 1944-1950
Kakhovka HES	Nova Kakhovka, Kherson region	334,8	1950
Dnister HES-1	Chernivtsi region	702	1973-1983
Dnister HES-2	Vinnytsia region	40,8	1982-2002
Dnister PSPS	Chernivtsi region	1296-1684	1983-2009
Tashlyk PSPS	Yuzhnoukrainsk, Mykolaiv region	453-649,5	1981-2007
Oleksandrivska HES	Yuzhnoukrainsk, Mykolaiv region	11,5	1999

2.5.4. Nuclear power

With its five nuclear power plants, Ukraine is among the most nuclear-dependent countries globally, ranking seventh in installed capacity as of 2022. Operating 15 nuclear reactors with a total capacity of 13,107 MWe, nuclear energy covers over 55% of its electricity consumption. With the exception of the South Ukraine (Yuzhnoukrainsk) nuclear plant located in the basin of the Southern Bug River, all other plants, including the Chornobyl, Rivne, Khmelnytskyi, and Zaporizhzhia NPP, are situated in the Dnipro River basin (WNA, 2024).

The nuclear plants currently operating in Ukraine were built during the Soviet Union period, designed in the 1960s and constructed during the 1970s-1980s. A cornerstone of the vision for rapid modernization and the pursuit of supremacy in the nuclear arms race of that time, nuclear power was considered a symbol of technological advancement in the USSR. All operating reactors are Soviet-designed VVER types, two of which are upgraded 440 MWe V-312 models, and the other is the larger 1000 MWe units – two early models and the rest V-320s. Today, Ukraine's nuclear power plants are operated by NNEGC Energoatom, the country's nuclear power utility, according to the nuclear safety regulations implemented by the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU).

The relation of Nuclear Power plants to water sources is not accidental. The availability of cooling water is a key factor in the location of both thermal and nuclear power plants. The most common types of nuclear power plants use water for cooling in two ways: (1) to convey heat from the reactor core to the steam turbines and (2) to remove and dump surplus heat from this steam circuit (WNA, 2020). In the first case, water is circulated continuously in a closed-loop steam cycle for the purpose of heat transfer from the core and hardly any is lost. However, in nuclear plants, there is an additional requirement for water cooling — both through primary routine cooling and the ECCS (Emergency Core Cooling Systems) — in the case of a shutdown, as heat continues to be generated from radioactive decay. The second function of water in a nuclear power plant is to cool the system so as to condense the low-pressure steam and recycle it. That is, as the steam in the internal circuit condenses back to the water, the surplus (waste) heat which is removed from it needs to be discharged by transfer to the air or a body of water (WNA, 2020).

The above provides a logical explanation as to why the banks of the Dnipro River were chosen for the erection of Ukraine's nuclear power plants during the Soviet times, particularly the Chornobyl and Zaporizhzhia NPPs. At the time of its construction, the Chornobyl NPP was the largest in Ukraine and one of the largest in Europe. The project, built on the banks of the Dnipro River tributary — the Prypiat River — included, among others, a large cooling pond, canals and other infrastructural facilities. The well-known Chornobyl catastrophe of 1986 in the 4th reactor was likely the most severe accident in the history of civilian use of nuclear energy. The remaining reactors remained in operation at reduced capacity before they were decommissioned throughout the 1990s (BASE, 2024).

Despite the tragic history of nuclear power in the country, and the risks posed by the Russian full-scale invasion with the occupation and attacks on nuclear facilities, the nuclear industry continues to play a defining role in Ukraine's energy system. Following the collapse of the Soviet Union and the aftermath of the Chornobyl disaster, Ukraine imposed a moratorium on the construction of new nuclear power plants in 1991. It was lifted just 2 years later and old nuclear projects were restarted. Zaporizhzhia-6 became operational in 1996, Khmelnytskyi-2 and Rivne-4 were completed with EBRD and EU loans and began operation in 2004. Construction of all 3 reactors started back in 1986. In 2024, amid the full-scale war, Ukraine's Energy Minister, German Galushchenko, announced that the construction of four new nuclear reactors will begin in the summer or autumn of 2024 on the site of the existing Khmelnytsky NPP in western Ukraine (Reuters, 2024). The country seeks to compensate for lost energy capacity due to the war with Russia, in particular the Zaporizhzhia NPP currently under russian occupation.

Figure 5. Photo of the Zaporizhzhia Nuclear Power Plant (2 cooling towers on the left and 6 VVER reactor buildings) and the Zaporizhzhia Thermal Power Plant (two tall smokestacks), viewed from across the Kakhovka Reservoir on the Dnipro River. Author: Ralf1969; Source: Wikipedia (Public Domain; CC BY-SA 3.0), 2009.

Name	Location	Number of reactors	Total Capacity (MWe)	Construction years
Rivne NPP	Varash, Rivne region	4 reactors	2,500 MWe	1980-2004
Khmelnitskyi NPP	Netishyn, Khmelnitska region	2 reactors	2000 MWe	1987-2004
Zaporizhzhia NPP	Enerhodar, Zaporizhzhia region	6 reactors	5700 MWe	1984-1995
South Ukraine NPP	Yuzhnoukrainsk, Mykolaiv region	3 reactors	2850 MWe	1982-1989
Chernobyl NPP	Prypiat, Kyiv region	4 reactors *decommissioned from 1991 to 2000	3515 MWe	1977-1983

2.5.5. Thermal power

Another major source of energy production falls on fossil fuels, namely coal, natural gas and oil, on which Ukraine's energy sector is still highly dependent. In 2020, the IEA reported that Ukraine possesses substantial conventional and unconventional hydrocarbon reserves: estimated at 9 billion tonnes of oil equivalent (Btoe), among which an estimated 5.4 trillion cubic meters (tcm) of natural gas reserves, more than 400 million tonnes (Mt) of gas condensate and 850 Mt of oil reserves.

These resources are largely concentrated in three regions: the Carpathian region in the west, the Dnipro-Donetsk region in the east, and the Black Sea-Sea of the Azov region in the south. Among these, the Dnipro-Donetsk region stands beyond the competition, accounting for 80% of proven reserves, approximately 90% of gas production, and most of Ukraine's coal. Ukraine's abundant coal reserves account for more than 90% of the country's fossil fuel reserves. They include the full range of coal types, from anthracite to lignite, thermal and coking coal (IEA, 2020).

While in 2023, the Ukrainian government reaffirmed its COP26 (Glasgow, 2021) commitment to phasing out state-owned coal power plants by 2035 (PPCA, 2023)), with its century-long history of oil, gas and coal production dependence on fossil fuels remains high to these days. Before the beginning of Russia's aggression against Ukraine in 2014, Ukraine's energy sector included a total of 15 thermal power plants and 49 combined heat power plants. Most of these were constructed during the Soviet period and remain operational.

The main stakeholders involved in the drilling, development, production, transportation, refining, storage and supply of fossil fuels in Ukraine include the country's largest company — the state-owned NJSC Naftogaz, but also Ukrtransgaz, Ukrgazvydobyvannya, Gas Transmission System Operator of Ukraine (GTSOU) and others. The electricity supply and transmission is dominated by the state-owned national electricity company United Energy System of Ukraine, but the private company DTEK also controls a large bulk of the market and numerous major power plants (IEA, 2020).

Figure 6: Photo of the Prydniprovska Thermal Power Plant in Dnipro viewed from the Southern bridge across the Dnipro River.
Author: Fulco Treffers, 2024.

Figure 7: Satelite image of the Trypillia Thermal Power Plant in Ukrainka (Kyiv region)
Source: Google Earth (Accessed: May 2024)

While the role of water in hydroelectric power generation is evident, its significance for other sources of energy generation, such as nuclear and thermal, is less straightforward. And yet, water-dependent thermal power plants generate the majority of the world's electricity – more than 81 per cent (van Vliet et al., 2016). These plants use fuels such as coal, gas or nuclear energy to make heat, which is then converted into electrical energy. For most thermal plants, large volumes of water are a crucial part of the process, cooling high temperatures and powering turbines with steam. Ukraine's thermal energy is no exception.

Although power plants require water for several processes, including, among others, steam cycle, ash handling, and flue gas desulfurization systems, most of the water requirements (usually about 90% of the total) are for cooling purposes (Global Water Forum, 2015). Similarly to nuclear power generation discussed above, thermal power plants require water for cooling which can be conducted in two ways: either (1) via a once-through cooling system, used to condense steam in the power plant, essentially absorbing heat and returning water to its source; or, alternatively, (2) via a recirculating (closed loop) cooling system, where most of the water is lost to evaporation, as water is continuously circulated through a cooling tower and a condenser. Ultimately, the amount of cooling required by any steam-cycle power plant is determined not by what resource it is fuelled (coal, gas or other) but by its thermal efficiency.

Many changes have occurred since 2014, when both Crimea and parts of the 'Donbas' were illegally occupied by Russia, and especially since 2022, when Russia launched its full-scale invasion against Ukraine. The many challenges, limitations and transformations will be discussed in the next sections and chapters of this report. Further disucssion about energy is addressed in mainly in sections *3.2 Energy Insecurity* and *4.4. Resilient Energy System.* What is important to note here, however, is that the role of the Dnipro River remains very significant for thermal power, as for nuclear and hydroelectric power discussed above.

Table 1: Ukraine's Thermal Power Plants; Source: based on data from open sources.

Name	Location	Capacity (MW)	Energy source	Construction year
Burshtyn TPP	Ivano-Frankivsk region	2300	Coal	1965-1969
Vuhlehirsk TPP	Donetsk region	3600	Coal, Gas	1972-1977
Dobrotvirsk TPP	Lviv region	600	Coal	1959-1964
Zaporizhzhia TPP	Zaporizhzhia region	3600	Coal, Gas	1972-1977
Zmiiv TPP	Kharkiv region	2175	Coal	1960-1969
Zuyiv TPP	Donetsk region	1270	Coal	
Kryviy Rih TPP	Dnipropetrovsk region	2820	Coal	1965-1973
Kurakhiv TPP	Donetsk region	1460	Coal	1936-1952
Ladyzhyn TPP	Vinnytsia region	1800	Coal	1970-1971
Luhansk TPP	Luhansk region	1450	Coal	1953-1969
Myroniv TPP	Donetsk region	115		
Prydniprovska TPP	Dnipropetrovks region	2400	Coal	1959-1966
Slovyansk TPP	Donetsk region	880	Coal	1971
Starobeshiv TPP	Donetsk region	2275	Coal	1961-1967
Trypillia TPP	Kyiv region	1800	Coal, Gas	1969-1972

Table 2. Urkaine's seven largest Combined-Heat Power Plants. Source: based on data from open sources.

Name	Location	Capacity (MW)	Energy source	Construction year
Kyiv CHPP-5	Kyiv	700	Gas	1971
Kharkiv CHPP-5	Podvirky, Kharkiv region	540	Gas	1979
Kyiv CHPP-6	Kyiv	500	Gas	1981
Severodonetsk CHPP	Severodonetsk	260		1952
Kremenchuk CHPP	Kremenchuk	255		1965
Cherkasy CHPP	Cherkasy	230		1961
Chernihiv CHPP	Chernihiv	210		1964

2.5.6. Renewable energy

With the global turn towards sustainable and renewable energy sources, amid growing concerns about carbon emissions and climate change, Ukraine has also seen the development of renewable energy sources (RES), especially in the years before Russia's full-scale invasion. With the highest technical RES potential in Southeast Europe (total of 874 GW, including 83 GW solar, 438 GW onshore wind, and 250 GW offshore wind), Ukraine's renewable energy sector has been developing rapidly (Energy Charter, 2023).

The share of RES (excluding large HES) in Ukraine's electricity production grew from only 1.8% in 2018 to 3% in 2019 and 8.2% in 2021 (Climatescope BNEF, 2019, 2020, 2021). In 2019, Ukraine featured in the Top-10 countries worldwide for the pace of development of renewable energy. In 2020, it entered the Top-5 European countries for the the growth of solar energy development. The same year, the Climatescope ranking by BloombergNEF listed Ukraine 8th among 104 countries for its investment attractiveness in low-carbon energy sources.

According to the IEA data discussed above, in 2021, the share of renewable energy sources (excluding hydropower, discussed separately) amounted to 6.5%. The installed capacity of RES amounted to 9,655 MW, while the total clean energy generated by RES constituted 12,804 million KWh. Solar sources delivered the majority (56%), followed by wind energy (33%), biomass and biogas (8%), and lastly, small hydropower sources (3%) (IEA, 2021; Razumkov Centre, 2022). As of 2021, the largest source of renewable energy in Ukraine was solar, with a total installed capacity of 7,586 MW, including rooftop solar installations. Wind energy remained second in installed capacity but was the fastest-growing sector.

Before the onset of russia's large-scale invasion, Ukraine had 34 wind farms with a total of 699 turbines generating green electricity at an average individual capacity of 3.5 MW, or a total of 1,672.9 MW. A less significant, albeit growing input was generated by biogas and biomass facilities with 21 MW of commissioned biogas installations and 43.1 MW of commissioned biomass stations, constituting a twofold increase compared to 2020. Lastly, the share of capacity from small hydropower plants (SHPPs) amounted to 14.6 MW (Razumkov Centre, 2022).

The geography of renewable energy facilities varies by energy source, corresponding to the natural potential of each region. Wind farms are predominantly located in the southern and southeastern regions of Ukraine, with approximately 85% of facilities situated along the Black and Azov Seas coasts. Solar generation is more widespread, yet still, about 60% of industrial solar power plants are concentrated in the southern and southeastern regions of Ukraine. In the early months of 2022, before Russia's military invasion, the leading regions in installed capacity of RES were the Dnipropetrovsk region (1350.06 MW), the Kherson region (1139.65 MW), and the Mykolaiv region (1121.16 MW), which collectively accounted for over 37% of all RES capacities in Ukraine (Razumkov Centre, 2022).

The development of Ukraine's national renewable energy sector has, of course, been rooted in the context of a broader global commitment towards energy transition in the face of climate challenges. Ukraine's contribution to the Paris Agreement and its National Economic Strategy approved in March 2021 confirm this, setting out objectives for a 25% share of RES in electricity by 2030, a 65% reduction of greenhouse-gas emissions from the 1990 levels and climate neutrality in 2060.

Figure 8: Photo of the Tyligulska Wind Power Plant (Mykolaiv region)
Author: unknown; Source: DTEK

Figure 9: Photo of Nikopol Solar Power Plant (Dnipropetrovsk region)
Author: unknwon; Source: DTEK

At the same time, Ukraine's transition to renewable energy sources has had a fundamental security rationale from the onset. The russian weaponisation of energy and energy 'blackmail' against Ukraine (but also many EU countries) repeatedly caused gas crises throughout the last decades, including in late 2021 and early 2022, confirming the importance of developing the bioenergy sector as an alternative capable of partially offsetting the natural gas deficit in terms of thermal and electrical energy production. Since russia's full-scale invasion in February 2022, the value of RES has been significantly transformed, as wind, solar, bio, small hydro, and hydrogen energy are seen as guarantees of energy security and independence for nations, with their cost significantly lower than that of fossil fuels or nuclear.

The relation of Ukraine's RES to the main topic of this report — the Dnipro River — is perhaps not as straightforward as with the more traditional energy sources discussed in the previous sections, as water does not play such a critical role for solar, wind, or biogas and biomass energy generation. However, it is precisely this factor that makes renewable sources of energy so important for our broader discussion in the following chapters of this report. Namely, the distributed and small-scale nature of RES, their low need for water consumption, and, not least, their contributions in dealing with climate-related challenges make them particularly interesting for future visions and strategies.

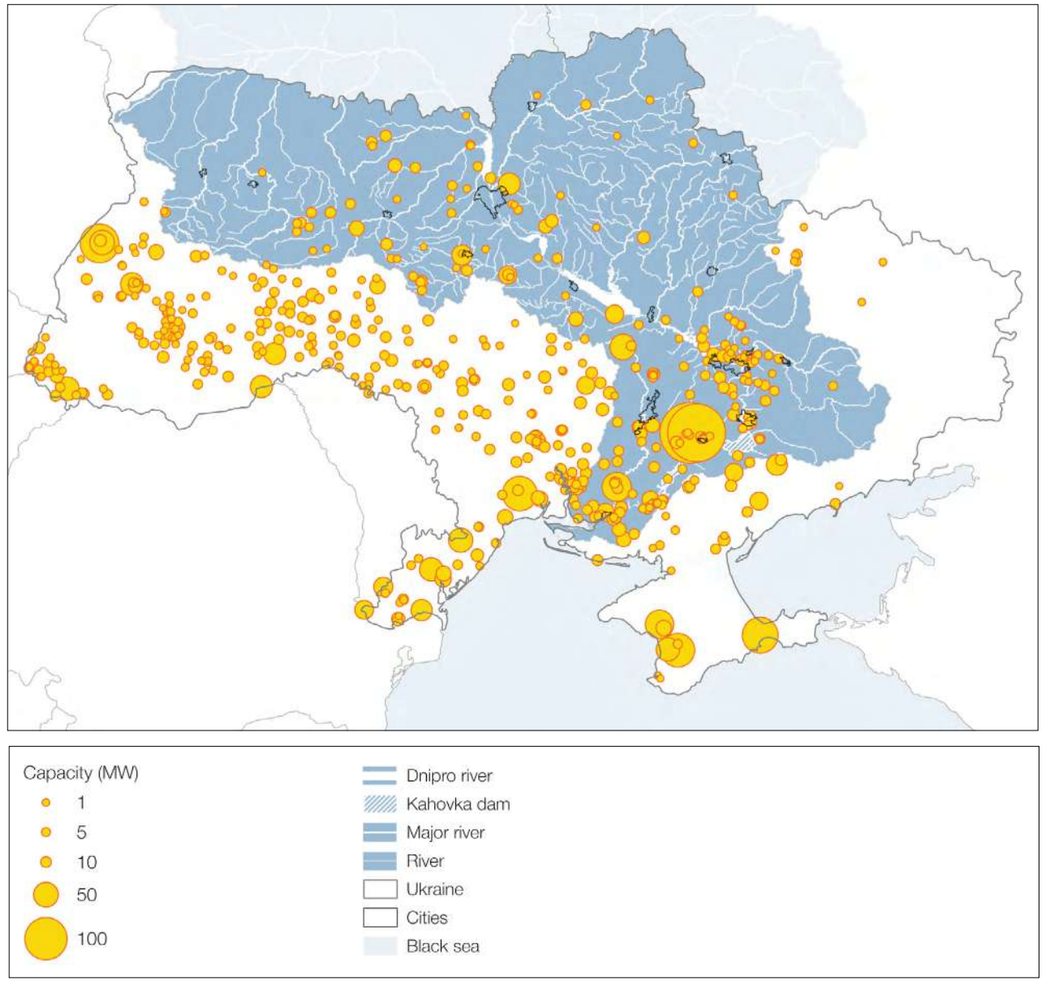


Figure 10: Map of major solar power plants in Ukraine
Author: Elaborated by Ro3kvit and Greenpeace CEE

2.6. Transportation, trade and mobility

2.6.1. The North-South Axis: Historical context

On the one hand, the Dnipro River is an important transport route itself. As seen in the previous chapters, the Dnipro River served as the main artery for trade and transportation for the Medieval Kyivian Rus to the Cossacks and beyond into modern times. With the Industrial Revolution and technological advancements, repeated attempts were made throughout the XVII-XIX centuries during the Russian Empire to increase the navigability of the river through the construction of canals and other infrastructure, including river ports for both freight and passenger transportation. Since the mid-XIX century, river navigation has developed significantly, transporting millions of passengers and millions of tons of goods per year.

Despite the progress, navigation was historically obstructed on the one hand by the famous Dnipro Rapids between the cities of Dnipro and Zaporizhzhia, but also by the climatic conditions, such as the duration of spring ice drift and the onset of winter ice formation. According to observation points set up on the river at the end of the 19th century, the average duration of spring ice drift on the Dnipro ranged from 5 to 12 days, with the longest ice drift occurring in the upper part of the river, between Dorogobuzh and Mohyliv.

In the middle section, however, between Kyiv and the rapids, autumn freezing did not affect navigation and always lasted much longer, averaging from 9 to 37 days, with the most prolonged period occurring between the mouth of the Prypiat River and the rapids (DRBMP, 2023).

As for the Dnipro Rapids, this natural limitation was resolved under Soviet rule during the twentieth century with the construction of the DniproHES dam in 1932, which flooded the rapids. After the Second World War, the construction of another five dams and the creation of the Dnipro Cascade significantly changed the river's natural flow, essentially transforming it into a series of regulated water reservoirs.

These transformations came with significant benefits, including for the navigation of the river, but also with significant costs discussed in detail in other chapters of this report. Overall, the construction of the Dnipro Cascade of dams and water reservoirs connected river ports with those of the Black Sea via a network of floodgates, considerably facilitating river-sea trade.

Figure 1: A series of postcards from 1974 displaying various locations along the Dnipro River [Комплект листівок 'Дніпро' (1974) БФ 28942 3 4-1147 15.05.1974]. The top photo is of the Kyiv riverside and the Kyiv River Port. The middle photo shows the River Port of Kherson and the embankment. The last bottom image shows the freight port in Zaporizhzhia. Source: Flickr/ Alexander Volok (Public Domain).

2.6.2. Navigation on the Dnipro River since Ukraine's independence (1991)

Before Russia's destruction of the Kakhovka Dam, which resulted in the loss of the Kakhovka Reservoir, the total length of the river fairway sections within the Dnipro River Basin in Ukraine, amounted to about 1,400 km, which constitutes two-thirds of the total length of the Ukrainian navigable river waterways. Within these, 1083 km are the Dnipro River itself, from the Dnipro Lyman in the south to the mouth of its tributary Sozh River on the border with Belarus. Other navigable fairways include river mouth areas of Dnipro's tributaries: the Prypiat River up to the border with Belarus (64 km), the Desna River up to Chernihiv (216 km) and the Samara River up to Novomoskovsk in the Dnipro region (30 km) (EUWI+, 2019, p.29). According to the State Statistics Service, 90% of transportation is carried out on the Dnipro River.

Generally, since the Soviet times, river transportation in Ukraine has critically decreased with both a shrinking and ageing of the river fleet and the condition of the corresponding infrastructure gradually deteriorating. Most river ports in Ukraine were built during the Soviet era and require modernization and significant capital investment.

Moreover, the length of waterways used for navigation has almost halved compared to 1990, from 4,000 km to 2,100 km. At the same time, the size of waterways with guaranteed depths has decreased from 3,100 km to 1,200 km in 2017 (Stets, 2017). Overall, for almost all indicators, river transportation ranks last in proportion to other modes of transportation. In the years preceding the full-scale invasion, inland waterway transport accounted for only 0.2-0.8% of all transportation in the country. Compared to European countries, these volumes are critically small. In Hungary, this figure is 4.2%; in Germany – 12.6%; and in Romania – 20.7% (Stets, 2017).

Nevertheless, river navigation continues to play a role in the overall mobility of the country, and some development has been observed in the last decade, especially in freight transportation. According to Ukrvodshhliah — the State Enterprise of Waterways of the Ministry of Infrastructure of Ukraine — the number of vessels that passed through the gateways on the Dnipro River amounted to 13,408 in 2017. Of all locomotive vessels, more than 90% made coastal voyages within the limits of the Dnipro River Basin, and the other 10% continued down to the Black Sea ports of Ukraine or beyond (EUWI+, 2019, p.29).

In a strategic push to enhance river transport capabilities, the Ministry of Infrastructure of Ukraine ratified the Strategic Plan for the Development of River Transport in 2015. This plan outlines significant river infrastructure upgrades and aligns national goals with European Union standards, ensuring a progressive outlook for Ukraine's river transport development. In December 2020, Kyiv adopted the Law "On Inland Water Transport," which permits foreign vessels to access Ukraine's internal waters, including its navigable rivers. The policy's original intent was to help develop the Ukrainian transportation sector and the broader economy (Ryzhenko, 2022).

Expanding further on new strategic initiatives, the development of the International Waterway E40 project is underway. This ambitious project aims to forge a navigable link between Gdansk in Poland and Kherson in Ukraine, traversing an extensive network that includes the Vistula River, the Western Bug River, the Prypiat River, and the Dnipro River. This initiative not only highlights the potential for increased maritime commerce but also signifies a pivotal step towards integrating Ukraine more closely with trans-European transport networks (EUWI+, 2019, p.29). However, the project faced much criticism for its ecological impact on the natural zones (Eco Rayon, 2022, Save Polesia, 2022). Although these developments are indicative of Ukraine's commitment to revitalizing and leveraging its riverine assets, due to the full-scale invasion, the geopolitical and ecological conditions became unfavourable for such plans and provoked a high demand for a comprehensive revision.

Figure 2: Photo of a barge entering the sluice in Zaporizhzhia. River port cranes seen in the background.
Author: Oleksandr Malyon

2.6.3. Passenger transportation

During the Soviet era, the river was a bustling conduit for both passengers and goods, buoyed by a fleet of advanced vessels, including hydrofoils like the “Raketa”, “Kometa”, and “Meteor”, which connected major cities such as Kaniv, Cherkasy, and Chornobyl (Korrespondent.net, 2015). Regular trips along the Dnipro and its tributaries, such as the Prypiat and Desna rivers, enhanced the accessibility of more remote regions. The routes served not only practical commuter needs but also catered to the increasing interest in domestic tourism. However, by the early 1980s, many of these river vessels were decommissioned, marking the end of regular passenger services (The Village, 2023). As we moved towards the end of the 20th century and into the 21st, the volume of passenger traffic along the Dnipro saw a dramatic decline. These high-speed vessels, marvels of their time, became uneconomical with the dissolution of the Soviet Union due to their high fuel demands and the cessation of state subsidies for such transport operations. Compared to 1990, passenger traffic has decreased thirtyfold, and in the 2010s, it did not exceed 500,000-550,000 passengers per year (EUWI+, 2019, p.29). This decline reflects broader shifts in Ukraine’s transport priorities and the availability of alternative transport methods that are more time-efficient. Many passenger ports in Dnipro-based cities have been abandoned or adapted for other uses. For example, the port in Kremenchuk, built in 1985, is occupied by Privat Bank services. Similarly, the passenger river port in Kyiv, situated in the Podil, stayed vacant for years until it was recently repurposed for the American University. Despite this downturn, the river has not been completely abandoned as a transport route. Before the recent Russian invasion, some navigation persisted, maintaining a link to its historic role as a transport artery. Today, the need for strategically reevaluating the Dnipro River as a transport route is apparent. Investment in modern, environmentally friendly vessels and the revitalization of port infrastructure could reinvigorate this historic waterway, enhancing its role in regional mobility and economic development.

Figure 3: A photo of a *Meteor* passenger boat entering the gates of the sluice at the Kakhovka dam, from a series of postcards from 1974 [Комплект листівок ‘Дніпро’ (1974) БФ 28942 3 4-1147 15.05.1974]. Source: at Flickr/ Alexander Volok (Public Domain)

Figure 4: Photo of the commercial hydrofoil *Meteor* boat passing by the Trukhaniv Island in Kyiv, approaching the Kyiv River Port, 1985. Author: Don S. Montgomery, U.S. Navy (RET.); Source: Wikipedia.org (CC US).

2.6.4. Goods transportation

After the fall of the USSR, the transportation of goods by river declined in Ukraine; however, the last few years and decades saw a gradual increase. According to available data, the total volume of river freight transportation in Ukraine in 2015 amounted to about 6 million tonnes. Still, already in 2021, this number almost quadrupled, reaching 20.6 million tonnes (UIFuture, 2023). A significant share of Ukraine's river trade flows on the Dnipro River. Accordingly, a sharp increase can also be observed in river transportation volume on Ukraine's main water artery, from 3.6 million tonnes in 2017 to 14.4 million tonnes in 2021 (EUWI+, 2019, p.29; UIFuture, 2023).

The majority of these volumes are attributed to the transportation of metals and mining products, agricultural products as well as other bulk cargoes, general cargo, and packaged goods (Ukrrichflot, no date). The recent increase, however, owes much to the development of grain handling, as the last decades have seen the establishment of various infrastructures by key agro holdings, including grain terminals, river ports and fleets, intended for the export of Ukraine's agricultural products. The development of grain transportation by river transport has enabled the development of a trans-shipment service - where a sea-going vessel is loaded from a river-sea class barge. This partially addressed the problem of insufficient depth in most Ukrainian seaports (UIFuture, 2023).

Before Russia's invasion, the Dnipro was a grain superhighway. Nibulon, one of Ukraine's biggest grain companies, used its fleet of 86 barges and tugboats to lug up to 3.7 million tons of grain from storage facilities along the river to ports on the Black Sea (WP, 2024). Before Russia's full-scale invasion of Ukraine, Nibulon operated 29 grain terminals throughout Ukraine, 9 of which were on the banks of the Dnipro River (Nibulon, no date).

With a fleet of about 100 vessels, including sea-river vessels, river barges and tugboats, the private shipping company Ukrrichflot is a major player in the river transport market, which also includes managing and operating 210,000 sqm of warehouses and the five largest river ports in Ukraine, four of which are on the Dnipro River: the Kherson, Nikopol, Zaporizhzhia and Dnipro river ports (Ukrrichflot, no date). Before the full-scale invasion, the company transported over 1.2 million tons of metals and 0.8 million tons of agricultural products, mainly intended for exports.

Overall, the nine major river ports on the banks of the Dnipro River are situated in the largest cities that are located along its banks: (from north to south) Kyiv, Cherkasy, Kremenchuk, Kamianske, Dnipro, Zaporizhzhia, Nikopol, Nova Kakhovka and Kherson, as well as the Chernihiv river port on the Desna river. Other river infrastructures include the Dniprodzerzhynsk River Port, Svitlivodsky River Terminal, Zernoport Myshurin Rig, Dniprorudne Pier, as well as numerous terminals in Pereyaslav, Vitove, Kamianka-Dniprovska, Kozatske, and others, which belong to various private industrial and agro-industrial companies including Nibulon mentioned above, but also companies like Hermes-Trading and UkrAgroKom involved in river goods transportation services.

Figure 5: Photo of Nibulon's "Khortytsia" Grain Terminal (Zaporizhzhia region). Commissioned in June 2017, it holds a storage capacity of 77,000 tons. Author: unknown; Source: Nibulon, www.nibulon.com

Figure 6: Photo of Nibulon's Terminal "Kozatska" (Kherson region). Commissioned in July 2012. it was designed for the storage and transshipment of grain and other agricultural cargo. In 2017, the storage capacities were expanded to 76,000 tons. In 2023, the branch was completely destroyed and flooded following the russian destruction of the of the Kakhovka dam upstream. Author: unknown; Source: Nibulon, www.nibulon.com

Established in 2005, the Administration of River Ports operates under the auspices of the Ministry of Infrastructure of Ukraine. It is the only state-owned enterprise in the field of river transport. Its mandate includes ensuring the preservation and effective utilization of river hydraulic structures, passenger fleets, and other state property and overseeing their construction, operation, repair and modernisation. Among its many activities and duties, the ARP is also responsible for collecting port charges, providing passenger and cargo transportation, towing operations, loading and unloading, vessel chartering, conducting instrumental surveys of major river infrastructure and others.

Transitioning to the broader economic context, the strategic role of the Dnipro River within Ukraine's navigation system cannot be overstated. Historically, the river's floodgates served as critical junctures linking Ukraine's marine ports on the Black Sea and the Azov Sea, as well as the river port of Mykolaiv. On February 23, 2022, on the eve of the Russian full-scale invasion, the toll for passing the floodgates was cancelled. However, navigation on the Dnipro has been halted since the Russian full-fledged military aggression, leading to significant disruptions. The destruction of the Kakhovka dam broke the river connection of the upper Dnipro with the Black Sea. These topics will be addressed in the following chapter. What is important to remember here is that the Dnipro River plays a central role in Ukraine's river navigation, further contributing to trade and economic development.

Furthermore, the Kakhovka sluice, being the last lock on the Dnipro that facilitated access to the open seas, played a vital role in this economic conduit. Its destruction by Russian forces closed the gateways critical for Ukrainian exports, emphasizing the strategic importance of these river pathways. Historically, disruptions have been a recurring theme, as seen during the Second World War when river navigation was completely halted. It was not until 1947 that the river was reopened for vessel traffic, underscoring the resilience and enduring significance of the Dnipro River through various epochs. As we proceed, this chapter will delve deeper into these topics, examining the ongoing challenges and strategizing for the future to rejuvenate and leverage the Dnipro River as a vital artery of Ukraine's economic growth and connectivity.

Figure 7: Photo of a barge and tugboats on the Dnipro River
Author: Oleksandr Malyon

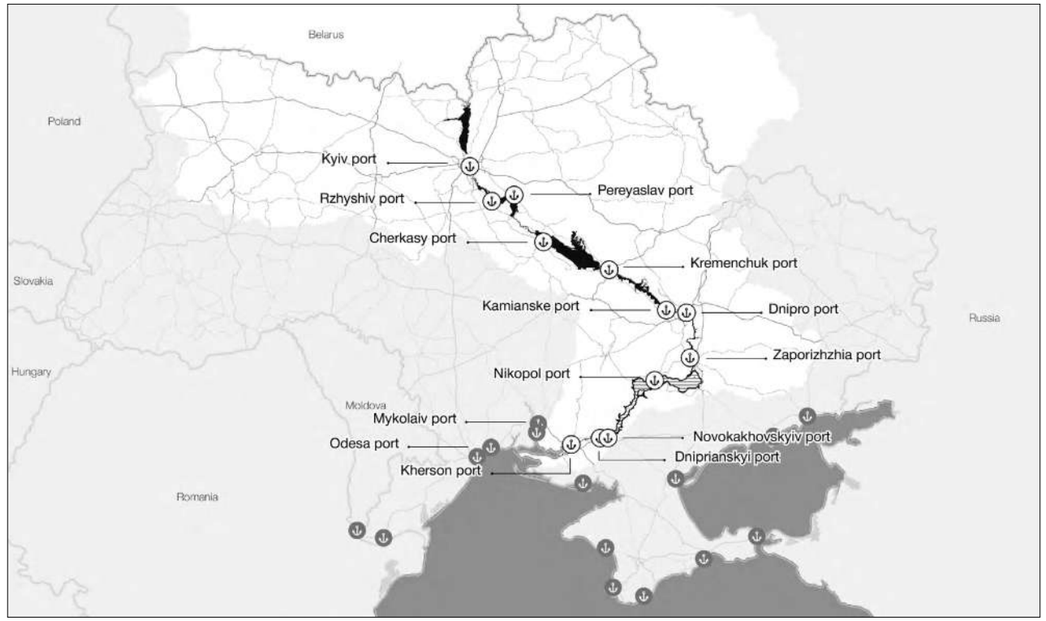


Figure 8: Map of the Ukrainian ports along thr Dnipro River, Black Sea and Azov Sea.
Author: Elaborated by Ro3kvit and Greenpeace CEE

2.6.5. An East-West divide? The Dnipro River within Ukraine's mobility system

The Dnipro River functions not only as an internal transport route but also as a critical component within the broader Ukrainian mobility and transportation framework. As outlined previously, the Dnipro River Basin encompasses regions where approximately half of Ukraine's population resides, totalling around 20.7 million individuals in 2017. This population is predominantly concentrated in major urban centres, including Kyiv, as well as other significant cities such as Dnipro, Zaporizhzhia, Kherson, Cherkasy, and Kremenchuk.

Prior to the full-scale invasion, the Ministry of Infrastructure focused on enhancing international transport corridors predominantly in the western parts of Ukraine, areas not intersected by the Dnipro River. Conversely, five international corridors traverse the Dnipro at major urban confluences in Kyiv, Dnipro, and Kherson (Figure 9). After the war's end, it is anticipated that these corridors will undergo reassessments with a strategic emphasis on further developments extending westward and southward.

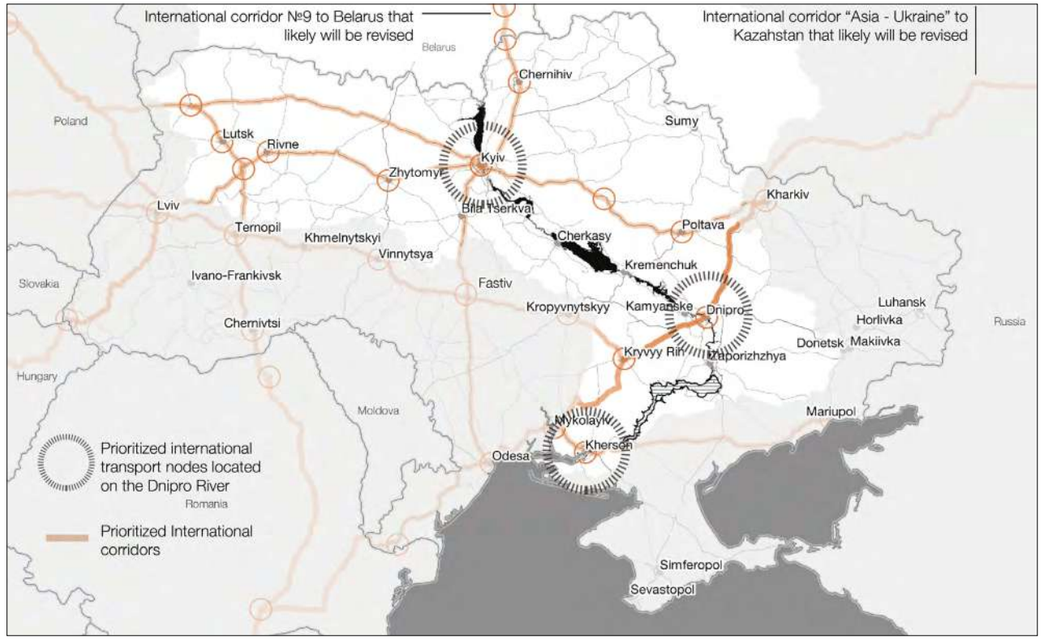


Figure 9: Map of the International corridors prioritized by The Ministry of Infratsructure in 2015 with highlighted transport nodes located on the Dnipro River. Author: Ro3kvit

Employing the Space Syntax research methodology, an analysis by Ro3kvit delineated various characteristics of Ukraine's transport network, such as Integration, Choice, and Connectivity (See Appendix 1 for a more detailed overview). This investigation covered nine regions along the Dnipro, including Kyiv, Chernivtsi, Poltava, Cherkasy, Kropyvnytskyi, Mykolaiv, Dnipro, and Zaporizhzhia. Findings indicate that pivotal connectivity nodes are primarily located in urban centres such as Kyiv, Kropyvnytskyi, Mykolaiv, Kryvyi Rih, Dnipro, and Zaporizhzhia, with the Kyiv region exhibiting the highest integration (Figure 10). This is mainly attributable to the numerous bridges spanning the Dnipro, which facilitate significant integration between the urban core and its surrounding agglomerations.

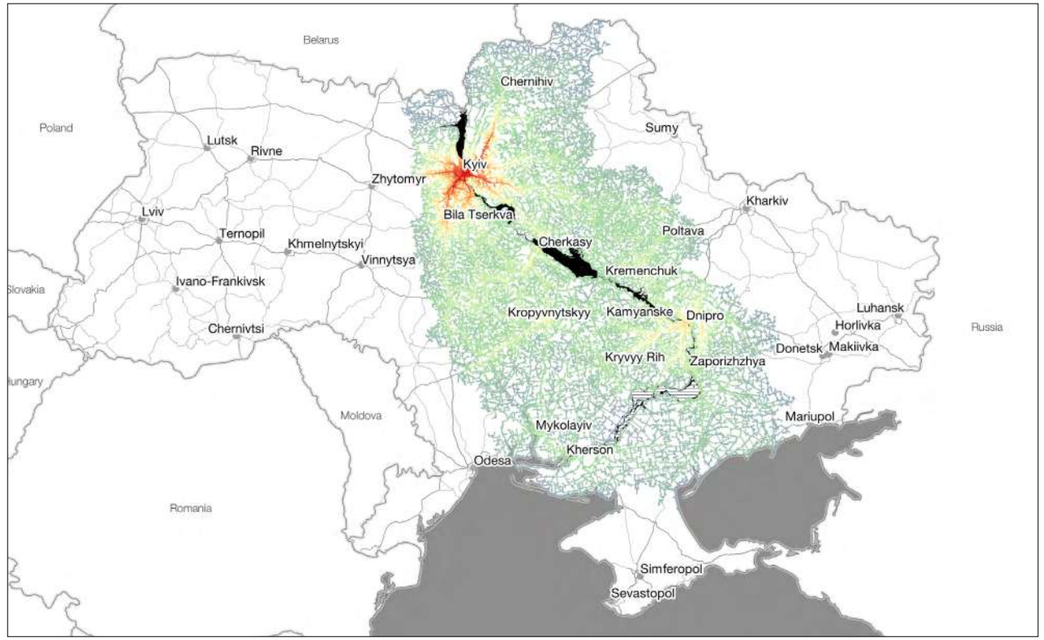


Figure 10: Space Syntax modeling, which includes new bridge next to Energodar and recovery of Antonivskyi bridge. Integration visualization. Author: Ro3kvit

2.6.6. Connectivity: The bridges across the Dnipro River

Connectivity between the right and left banks of the Dnipro River is based on bridges. Currently, there are 30 existing crossings along the Dnipro River, 3 of which are still under construction. The oldest preserved one is Kriukiv Bridge in Kremenchuk city, constructed in 1872. Despite the current national oversight regarding the development of cross-river infrastructure, we encourage regional and local authorities to explore various strategies to enhance connectivity across the Dnipro River. At the urban scale, the river often becomes a significant barrier, compounded by outdated transport infrastructure, particularly at bridge crossings. This is exemplified by Kyiv, where mobility, quality of life and the clearness of the environment are notably compromised during peak traffic periods. In this case, the Dnipro River “divides” the city. To address these challenges, the Ro3kvit team conducted modelling in-between regional and urban scale for Kremenchuk city and Kyiv city to illustrate potential infrastructural modifications that could alleviate traffic congestion (see Appendix 1 for a more detailed overview). However, the models did not show substantial improvement with adding two bridges, underscoring the necessity for a holistic approach. Solutions should not only consider the construction of new infrastructure but must also encompass modifications to urban policies that promote sustainable public transport options and other viable alternatives.

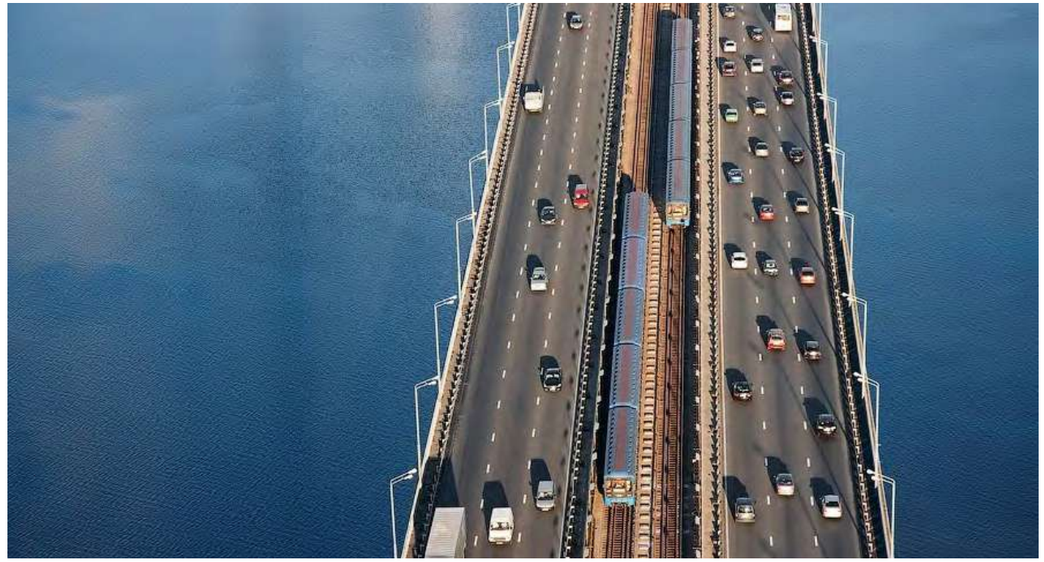


Figure 11: Photo of the Southern Bridge in Kyiv which both metro and automobile linkage
Author: Oleg Totskiy ; Source: Wikipedia.org (CC BY-SA 3.0)

Figure 12: Photo of the Antonivsky Railway Bridge in the Kherson region, 2017
Author: Yevhenii Ihnatiev ; Source: Wikipedia (CC BY-SA 4.0)

Figure 13: Photo of the Darnytsia Bridge in Kyiv, 2019
Author: Maksym Kozlenko ; Source: Wikipedia (CC BY-SA 4.0)

Figure 14: Photo of the Paton Bridge in Kyiv in winter, 2022
Author: Yana Leonenko ; Source: Wikipedia (CC BY-SA 4.0)

Figure 15: Photo of the Second Preobrazhensky Bridge in Zaporizhzhia
Author: Oleksandr Malyon

Figure 16: Photo of the construction of the New Bridge across the Dnipro and Old Dnipro in Zaporizhzhia, 2015
Author: Teteria Sonnna ; Source: Wikipedia (CC BY-SA 2.0)

Table 3. List of bridges across the Dnipro River; Source: based on data from open sources

Name	Location	Use type	Construction year
Nedanchychi Rail Bridge	Belarus-Ukraine border	Rail	1930
Slavutych–Kamaryn border crossing	Belarus-Ukraine border	Auto	1987
Kyiv HES Dam	Vyshhorod, Kyiv Oblast	Auto	1964
Pivnichniy (North) Bridge	Kyiv	Auto	1976
Petrivsky Rail Bridge	Kyiv	Rail	1929
Podilsko-Voskresenskiy Bridge	Kyiv	Auto & Metro	under construction
Parkovy Pedestrian Bridge	Kyiv	Pedestrian	1957
Metro Bridge	Kyiv	Auto & Metro	1965
Paton Bridge	Kyiv	Auto	1953
Darnytskyi Rail Bridge	Kyiv	Rail	1949
New Darnytskyi Bridge	Kyiv	Auto & Rail	2010
Pivdenny (South) Bridge	Kyiv	Auto & Metro	1990
Kaniv HES Dam	Kaniv	Auto & Rail	1972
Cherkasy Dam	Blahodatne–Cherkasy	Auto & Rail	1960
Kremenchuk HES Dam	Svitlovodsk	Auto & Rail	1959
Kriukivsky Bridge	Kremenchuk	Auto & Rail	1872
New Kremenchuk Bridge	Kremenchuk	Auto	under construction
Middle Dnipro HES Dam	Kamianske	Auto and Rail	1964
Livoberezhny (Left Bank) Bridge	Kamianske	Auto	1996
Kaidatsky Bridge	Dnipro	Auto	1982
Amursky Bridge (Old Bridge)	Dnipro	Auto & Rail	1884
Tsentralny (Central) Bridge	Dnipro	Auto	1966
Merefa-Kherson Bridge	Dnipro	Rail	1932
Pivdenny (South) Bridge	Dnipro	Auto	2000
Dnipro HES Dam	Zaporizhzhia	Auto	1932
Preobrazhensky Bridge (two bridge crossing)	Zaporizhzhia	Auto & Rail	1952
New Bridge across Dnipro and Old Dnipro	Zaporizhzhia	Auto	under construction
Kakhovka HES Dam	Kozatske–Nova Kakhovka	Auto & Rail	1972
Antonivskiy Bridge	Pishchanivka–Prydniprovske	Rail	1952
Antonivskiy Bridge	Oleshky–Antonivka	Auto	1985

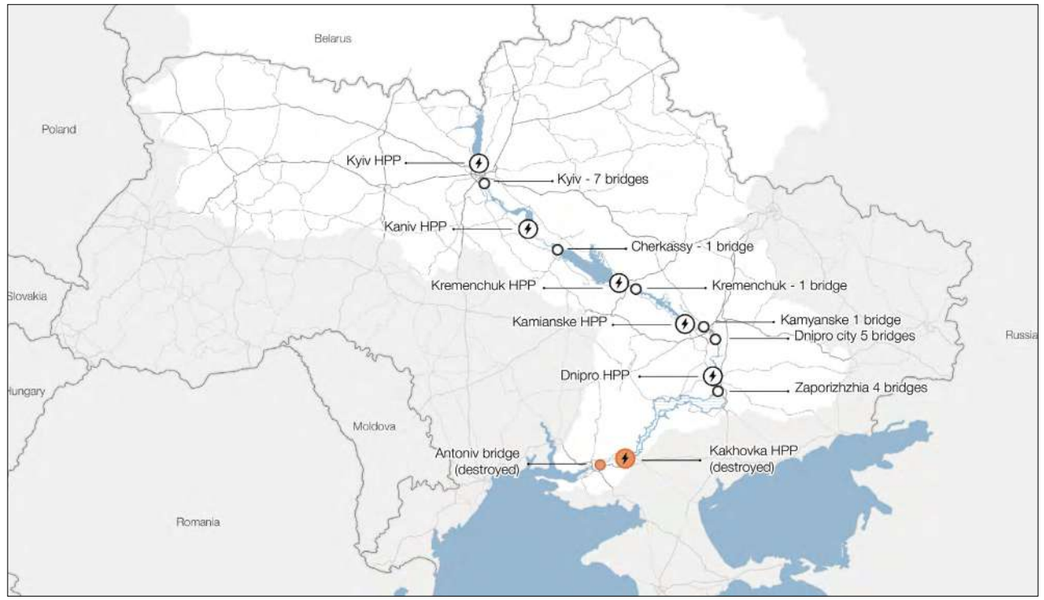


Figure 17. Map of bridges across the Dnipro River
Author: Elaborated by Ro3kvit and Greenpeace CEE

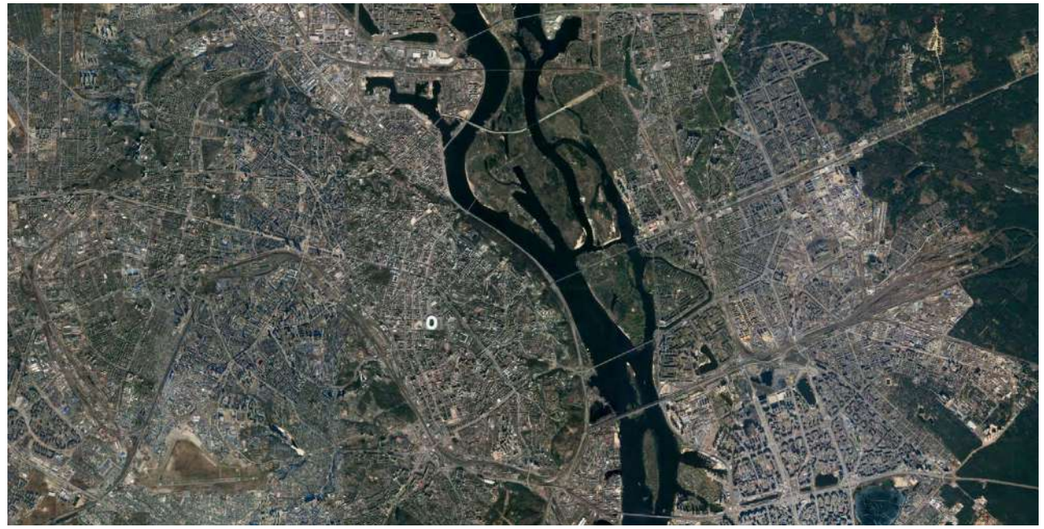


Figure 18. Satelite view of Kyiv, showing all 8 bridges across the Dnipro River.
Source: Google Earth (Accessed: May 2024)

2.7. Tourism and recreation

2.7.1. Introduction and overview

While claiming that the Dnipro River itself is a very popular destination for tourists from around the world would be an overstatement, it is undoubtedly one of the main features that every person visiting the cities along its banks remembers. In Kyiv, as in the many towns and villages that are located along its banks, the Dnipro River is an inseparable element of identity. Anyone who has crossed the river on one of the bridges or stood on the banks of one of its vast water reservoirs is impressed by the might of the Dnipro River.

Indeed, it is not just a source of water for our various human needs or a waterway for navigation and trade. It is also a very important feature of Ukraine's natural beauty, a long continuous blue line crossing picturesque landscapes, impressive cityscapes, historical landmarks, and charming countryside. Like a string, it flows down, connecting the various wild natural places with historical settlements and monuments.

Of course, beauty is subjective. But the many activities linked to the Dnipro River hint towards the immense recreational value that the river offers both for local residents and tourists from around the country and abroad. Natural landscapes, recreational areas, historical landmarks, fishing, water activities, and other aspects make the Dnipro River an attractive destination for tourism in Ukraine, offering something to locals and tourists alike.

2.7.2. Natural landscapes and ecotourism

The Dnipro River flows through diverse landscapes, from the northern forest-steppe to the southern steppe, creating diverse enchanting views and panoramas that attract locals as well as tourists. With its rich diversity of plant and animal species, the Dnipro River has attracted nature lovers, making it a popular choice for "ecotourism" long before the term itself began to be used. Throughout history, thousands of people have come to the river to escape from busy urbanity and explore the natural environment in all its beauty and diversity.

Arguably, one of the most remarkable natural wild beauties of the Dnipro River and Ukraine in general was the famous Dnipro Rapids, located between the cities of Dnipro and Zaporizhzhia. Along almost 100 km, powerful granite formations of the 3 billion years old Ukrainian crystalline shield (see 1.1. Physical Geography) emerged from the water in the form of countless rocky obstacles, transforming the river into a dangerous yet fascinating scenery. The Dnipro Rapids were considered one of the natural wonders of the Old World. Famous historical figures travelled great distances and deliberately came to Ukraine to see this unparalleled spectacle of magnificence, which was impossible to forget (Spadok, 2017). Famous Ukrainian historian Mykola Kostomarov wrote, "The roar of the water from the rapids, when it reaches the village, is so strong that it interferes with hearing words in conversation" (Local History, 2023).

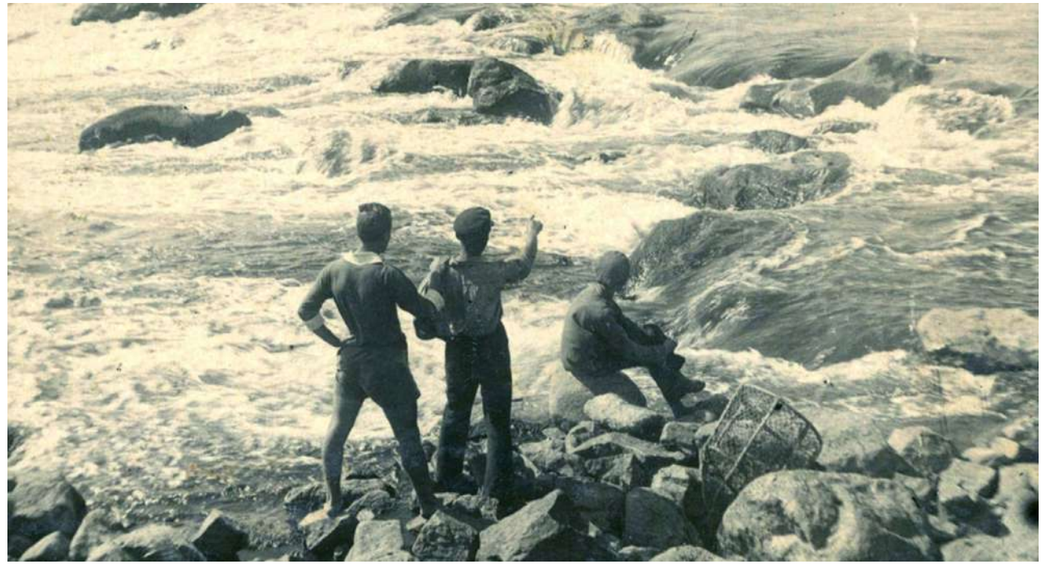


Figure 1: Dnipro Rapids in the 1920s, Postcard [cropped]
Author: unknown (Public Domain) ; Source: Dnipro Museum of the History of Lotzamans; Accessed at: Wikipedia.org

Figure 2: Photo of the Tukhaniv Island on the Dnipro River seen from the right bank, 2012. On the foreground the pedestrian bridge, and on the backghround the Podislky and Norther birdges. Author: Valeriy Ded; Source: Wikipedia.org (CC BY-SA 3.0).

Throughout history, they have been described by many cultural and historical figures, including the French cartographer de Beauplan (see 1.2. Historical overview). According to the Ukrainian poet Yar Slavutych, Taras Shevchenko crossed the Rapids together with the lotzmans. While, towards the second half of the XIX century, the Dnipro Rapids started attracting Ukraine's literary community, including Marko Kropyvnytskyi, Adrian Kashchenko, Mykola Kulish, Olena Pchilka, Dmytro Yavornytskyi, Ivan Nechui-Levytskyi and others (Local History, 2023).

With the emergence of tourism in the late 19th to early 20th centuries, the Rapids quickly became a tourist mecca for all who visited the region. However, they gained particular popularity in the late 1920s, when the Soviets started to build the first dam across the Dnipro River, which would eventually see the rapids submerged underwater in 1933. In these last few years, thousands of people from across the country have come to see the Rapids (Vlasov, 2015).

Today, despite the recognition of their natural and cultural significance, the Dnipro Rapids remain underwater, like many other parts along the river. Throughout the decades of Soviet rule, following the Second World War, the construction of the cascade of dams led to the flooding of most of Dnipro River's natural landscape on the territory of Ukraine, with thousands of hectares of natural river ecosystems flooded by the waters of large reservoirs. Along with the Dnipro Rapids, forestland, steppe, and riverbanks were lost, along with the many species that inhabited them. This major transformation of the river meant, of course, the loss of natural, ecological and cultural heritage (which will be discussed amply in the following chapters), but the Dnipro River, at times, preserved its natural shape, and at other parts, reshaped into a series of giant "seas", continues to attract people in its reinvented form.

In the modern days, those parts of the Dnipro River that preserved their natural shape, such as the Dnipro River Delta, but also Dnipro's main tributaries, Desna and Prypiat, continue to offer untouched natural beauty with abundant and rich wildlife and vegetation. Various kayak and boat tours have been organised for those eager to explore the river from the water. At the same time, while they have taken much of the natural beauty underwater, the vast waters of the reservoirs passing through cities and countryside have also become the new features of the landscape.

While there is still a lot of potential for improvement, ecotourism continued to develop actively in Ukraine before the full-scale invasion of 2022, with numerous tours organised by various private companies and personal initiatives. Government strategies for developing river tourism remained rather limited, and infrastructure (such as hotels, campsites, roads, pathways, and viewpoints) remains underdeveloped. While lacking infrastructure and amenities is undoubtedly a significant limitation to the successful development of tourism (and ecotourism) on the Dnipro River, one could also see this as a potential advantage in that some of the landscape remains unspoilt. All in all, it is essential to remember that the natural beauty and diversity of the Dnipro River constitute an important source of its tourist and recreational value for humans.

Figure 3: Photo of the Dnipro River (Kaniv Reservoir) south of Kyiv near Rzhyshchiv
Author: unknown; Source: Dovkola Media

Figure 4: Photo of people camping on the banks of the Dnipro River (Kyiv region).
Source: Dovkola Media

2.7.3. Recreational areas

While some places along the Dnipro River remain wild, a large part of its banks have also been appropriated by humans throughout the centuries for various recreational purposes. Both in urban and rural areas, the banks of the Dnipro River feature beaches, parks, sports facilities, and various other infrastructure for relaxation and entertainment. These places become particularly popular in the hot summer months, mostly among local users and residents. Many recreational areas that exist today are a legacy of Soviet times. The quality and size of these amenities vary, with some needing to be updated and developed and others adequately maintained and renovated. During Ukraine's independence, some new recreational areas were created, too.

Nevertheless, the Dnipro River continues to attract local citizens and guests. For instance, a popular place of recreation in Kyiv is the famous Trukhaniv Island, spanning 450 hectares and stretching 5 km from north to south. In the vicinity of the historical Podil district of the capital, the Dnipro River flow is divided into two parts. It is accessible from both banks by automobile and metro bridges and a pedestrian bridge. The island has several beaches, many sports grounds hosting local sports events, water sports, restaurants, cabins, and many kilometres of bike and pedestrian routes. Trukhaniv Island is just one, albeit good, example that underscores the high importance and potential of the Dnipro River in responding to the demand for recreational spaces for the population of dense urban centres. Similar examples include the famous Khortytsia Island in Zaporizhzhia or the Monastyrskyi Island in Dnipro. Of course, recreational spaces don't only occupy islands but also spread along the riversides, bays and canals.

The recreational quality of the Dnipro River has also been addressed in the more rural and natural places around the capital. During the Soviet times, the banks of the Dnipro River were chosen to construct various sanatoriums (in other words — resorts with recreational and medical facilities). Around the capital, these include the Khvylia, Zhovten and Koncha Zaspa sanatoriums situated south of Kyiv. Similar complexes are found in other cities along the Dnipro River, too. While some sanatoriums continue to operate and their territories are open to the public, others have been privatised to be repurposed or renovated. At the same time, new resorts have been developed by the private sector in the last decades, such as Shelest north of Kyiv, or Selena family resort near Cherkasy.

Figure 5: Photo of beaches on the Dnipro Islands in Kyiv
Author: WDKeeper; Source: Wikipedia.org (CC BY-SA 3.0)

Figure 6: Photo of the beach in Rzhyshchiv (Kyiv region)
Source: Dovkola Media

2.7.4. Fishing Culture

As seen in 2.3. Agriculture and fishing, like most rivers around the world, the Dnipro River has been a source of food for a long time, with a fish industry contributing to local trade and economy. Yet, aside from industrial fishing, the Dnipro River is also a renowned destination for many fishing enthusiasts who practice fishing as a form of culture and recreation. The opportunities for fishing are very diverse. You can fish independently or with assistance from third parties: numerous companies offer fishing tours and equipment rentals and organise fishing competitions. However, many still prefer to go fishing on their own or in the company of other fellow fishing enthusiasts. You can easily spot fishermen patiently waiting for a catch in many cities along the Dnipro River. While some prefer the early morning, finding their secret places to experience the meditating silence of catching the fish, many can still be easily seen right on the central beaches, riverbanks, and bridges, undistracted, amidst the noise of vacationers, passing yachts, jet skis, and cars (Bereg, 2020). All along the Dnipro River, one can see local fishermen on the embankment or in their little boats. They are trying to catch some of the 70 fish species swimming in the Dnipro. The lower part of the river is richer in fish — about 60-65 species are found there, while around Kyiv, about 40. The most common species are carp, bream, esox, sheatfish, roach, perch, and migratory and semi-migratory fish (herrings, sturgeon, etc.) (EUWI+, 2020, p.30).

Figure 7. Photo of fishermen on the Dnipro River in Kyiv, left bank, 2009
Author: Mstysla Chernov; Source: Wikimedia (CC BY-SA 3.0)

Figure 8. Photo of old wooden boats used by dishermen on the Dnipro River (Cherkasy region)
Author: Oleksandr Malyon

2.7.5. Water activites

With its many canals, lakes, bays, and ponds, as well as large sea-like reservoirs, the Dnipro River offers diverse opportunities for water activities, from yachting and sailing to smaller boats, jet skis, kayaks, SUPs, and paddles, as well as more extreme sports such as wake-surfing or water skiing. Many private clubs and companies offer the opportunity to experience these various activities on the Dnipro River.

The Trukhaniv Island area in Kyiv is a popular destination for more extreme water sports. Several clubs and rental services offer equipment and boat rides for water-skiing and wake-surfing enthusiasts, while the “X-Park” located on the Dnipro River is well-known for featuring a cable park system that allows wake-boarders to practice and perform tricks without the need for a boat. It is not uncommon to see jet skis in the Dnipro River, including right across Kyiv’s central embankment. In the summer, this stretch of the river can be full of sailboats, yachts, and water various sports.

For those who prefer more relaxing and calming water activities, the area around Hydropark in Kyiv is ideal for stand-up paddle boarding. Calm waters and beautiful scenery make it a perfect spot for leisurely paddling. Several rental services provide SUP boards and offer guided tours. A prominent location for rowing, sculling, and dragon boat racing is the Kyiv Rowing Club, which hosts numerous national and international rowing competitions and training programs for both beginners and competitive rowers.

The favoured places for sailing and yachting are of course the vast reservoirs, which provide large surfaces and beautiful sunsets. Aside from sailing and yachting, the Dnipro Reservoirs are a favoured location for windsurfing and kitesurfing. The wide open water and consistent winds create perfect conditions for these sports. Clubs like “Dnipro Windsurfing Club” offer lessons and equipment rentals and regular competitions are organised.

These various examples are just some of the many activities that are contemplated along the Dnipro River. Yet they highlight the diverse and vibrant water sports culture along the Dnipro River, showcasing specific locations and services that cater to both locals and tourists looking for aquatic adventure and recreation.

Figure 9. Photo of people engaged in water activities on the Dnipro River in Kyiv
Author: unknown ; Source: provided by X-Park

Figure 10: Photo of a boy wakeboarding on the Dnipro River in Kyiv’s X-Park
Author: unknown ; Source: provided by X-Park

Interviewing
Dmytro Ivanov

Journalist civic activist
57 years old
Lives in Kyiv

I first saw the Dnipro when I was a child. We spent a lot of time at the river—swimming, sunbathing, and rowing. My personal relationship with the Dnipro began after I graduated from university. As a journalist, I covered many topics, but one of my personal hobbies was sailing, so I wrote a lot about sailing in Kyiv. I met the people who created the Kyiv Yacht Club. Watching a frigate glide down the Dnipro in Kyiv is a breathtaking sight. Regattas aren't possible right now because of the war, but I used to participate in them.

Once, I was sent to cover one of the largest regattas in Ukraine, the Big Dnipro Cup. We sailed from the city of Dnipro to Odesa with 20 or 30 yachts participating. The lead yacht I was on, called *Staryy Lotsman* (Old Pilot in Ukrainian), strayed a bit from the fairway and got caught in poachers' nets. We were stuck for several hours until help arrived. These nets, which are still illegally placed across the Dnipro, are another environmental problem that needs to be addressed.

If you want to experience the real Dnipro, you need to visit the old islands. The best way to reach them used to be by hydrofoils like the *Raketas* and *Meteors*.

I remember the last day of regular river service on the Dnipro. It was August 31, 2002. I was a passenger on the Voskhod hydrofoil, which left Kaniv, picked me up in the village of Hryhorivka, and took me to the Kyiv River Port.

Today, there's still a small group of hydrofoil enthusiasts. An almost completely repaired hydrofoil is waiting to sail again on the Dnipro once we win the war.

Figure 11: Photo of yachts on the Dnipro River in Kyiv
Source: Ukraïner

Figure 12: Photo of yachts on the Dnipro River at the Kyiv embankment. On the background – the pedestrian bridge to Trukhaniv Island. Source: Ukraïner

2.7.6. Passenger boats and cruises

As mentioned in 1.2. Historical overview, since the XIX century, passenger boats have served as a popular mode of transport, competing with the railways and connecting cities along the Dnipro River with those of the Black Sea and beyond. Aside from their practical utility, river journeys were also a great tourist attraction. At the height of its success in the mid-XIX century, the Steamship Company of the Dnipro River and its tributaries transported 2 million passengers annually.

In the Soviet times, river passenger transportation continued to develop and was extremely popular. With the erection of the Dnipro Cascade of reservoirs, new cruise ships started offering long trips from Kyiv to Odesa and Crimea, attracting tourists from around the USSR. In the late 1950s, along with the "Meteors" and "Voskhods", river passengers were introduced to a technological marvel – hydrofoil boats called "Raketa". These high-speed vessels transported people along the Dnipro River both downstream to Kaniv and Cherkasy and upstream to Chornobyl and Chernihiv, also operating on Dnipro's tributaries Prypiat and Desna Rivers, being popular among locals and visitors (Korrespondent, 2015).

It is a fact that riverine passenger transportation is very underdeveloped today. With the dissolution of the Soviet Union, the Raketa, Kometa, and Meteor, like most other boats, quickly disappeared from routes due to their high and unaffordable fuel consumption. Most, if not all, large passenger vessels on the Dnipro River are outdated and expensive to maintain. Nevertheless, in the last decades, several cruise ships offered 13- and 8-day tours from Kyiv to Odesa and Crimea. For instance, during the 30 years of its operation, the private company "Chervona Ruta" has served around 130 thousand passengers from 42 countries on its "Princess of Dnipro" and "Rosa Victoria".

In the last few decades, there have also been several attempts to revive passenger transportation, such as the Nibulon passenger route circulating from Kherson to Nova-Kakhovka, which put the famous "Raketa" back on the water. Since 2017, the "Nibulon Express" has transported 120,000 passengers; however, water transportation on the Dnipro River had to be halted due to the ongoing war. Despite the incomparable traffic in the water sector and years of underinvestment, the Dnipro River retains a vast potential for passenger navigation.

Figure 13: Photo of Nibulon Express-1 on the Dnipro River in Kyiv.
Author: Oleksandr Malyon

Figure 14: Photo of the Polissia-5 boat on the Dnipro River, approaching the gates of the Kaniv sluice
Author: Oleksandr Malyon

2.7.7. Historical landmarks

Learning from history is crucial in the development of a country. The physical environment that surrounds us is a tangible testament to the centuries and millennia of historical events which are part and parcel of a nation's identity. Throughout the centuries, much of Ukrainian historical heritage has been forcefully erased and destroyed by the totalitarian regimes that ruled over these lands: first the russian empire, then the Soviet Union, and now the russian federation. Many historical landmarks have been lost, from Skythian burial mounds to medieval castles and churches, Cossack siches, whole villages and whole museums destroyed or looted. Despite that, overlooking a long history of ups and downs, the banks of the Dnipro River remain the home to some of Ukraine's most important and symbolic places.

Throughout the Dnipro River and its basin, numerous historical sites can be found, from entire cities to historical castles and fortresses, churches, monuments, and various other landmarks that offer interesting excursion routes for tourists. These places mark historical events and give insight into how life was in different eras. Documenting the many cultural and historical landmarks along the Dnipro River is a whole task in itself, which requires a lot of time and effort to reach something close to a comprehensive account. While it is not the intent of this research to focus on this, it is something the authors of this report would love to see done and something that would be of great value to the development of Ukrainian culture at large.

In talking about historical landmarks, it is impossible not to mention the famous Khortytsia Island in Zaporizhzhia. Stretching 12.5 km and spanning 3000 hectares, it is a place of unique natural importance, being the first in Ukraine to get the status of a national reserve. But, not least importantly, located on the historical Dnipro Rapids, Khortytsia Island is also a symbolic place for Ukraine, offering a window into the past centuries. Today, you can find 28 ancient Skythian burial mounds there (which, although much fewer than the 129 recorded here in the early 20th century, are still a lot) with stone sculptures called "babas" (Ukrainer, 2019. In the last decades, many artefacts from the Medieval Kyivian Rus have also been found in the Dnipro River itself, such as well-preserved wooden boats and swords, including a rare "Ulfber's" sword (one of 170 worldwide) dating to the 9-11th centuries, presumably belonging to prince Svyatoslav (Ukrainer, 2019).

Most importantly, Khortytsia is known for its Cossack heritage, serving as the historic Sich of the Zaporizhzhian Cossacks throughout the XV to XVII centuries. Like with most of the Cossack heritage in Ukraine, little could have been preserved, as during the Russian and Soviet empires after it, the Cossacks and their culture were targetted, and the Siches were destroyed. Along the Dnipro River, x siches existed at different times on the territories that, since 1956 and until very recently, were flooded by the waters of the Kakhovka reservoirs. Nevertheless, Khortytsia Island offers traces of Cossack tradition with its historical and cultural complex "Zaporizhzhia Sich", featuring striking architectural reconstructions and artefacts. The famous Khortytsia Island in Zaporizhzhia remains a unique place on the Dnipro River, preserving the history and culture of the Cossacks, and is undoubtedly a place worth a visit. It is, of course, not the only place.

Figure 15: Photo of the *Church of the Intercession of the Holy Mother of God in Sich* on the Khortytsia Island, overlooking the DniproHES dam, Zaporizhzhia. Author/Source: Ukraïner, 2019

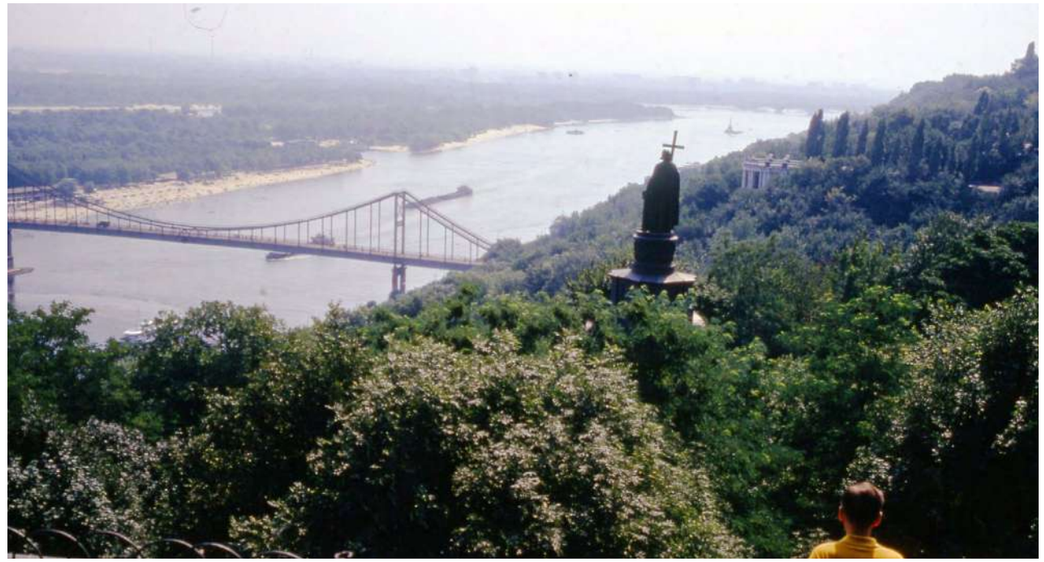


Figure 16: Photo of the statue of Volodymyr the Great in Kyiv, overlooking the Dnipro River, 1972.
Author: Thomas T. Hammond; Source: Wikipedia (CC BY-SA 4.0)

Figure 17: Photo of the Trakhtemyriv peninsula and the Kaniv Reservoir from an airplane porthole.
Source: Oleksandr Malyon

While the Soviet regime was a significant contributor to the destruction of native Ukrainian culture, it also left its mark on the country and the regions, which cannot be ignored. Aside from its vast infrastructural projects, such as the many dams and bridges, which themselves are interesting to observe and study, the soviet era left us with many architectural and sculptural monuments. To note an example, one may come across the famouso Memorial “Bukryn bridgehead” in Balyko-Shchuchynka, honouring soldiers who had died in the Battle for the Dnipro during the Soviet counteroffensive against Nazi troops during the Second World War. There are many other examples, spread across cities and countryside. But this specific example also helps to realise the complexity of Ukrainian history. The Memorial is situated by the Trakhtemyriv peninsula on the Dnipro River, now a Regional Landscape Park. This place has been inhabited by people for over 120 thousand years and holds a multilayered heritage shaped by ancient civilisations, the Kyivian Rus, the Cossacks, and more modern history.

Everywhere along the Dnipro River, historic settlements have been shaped by the centuries of urban and political transformations, with cities like Kyiv, Dnipro, Zaporizhzhia, Kherson and others displaying architectural objects dating back to the Middle Ages, alongside 17th-century baroque churches, 19th-century neo-renaissance buildings and palaces, modernist and brutalist edifices from the soviet era and, of course, more modern and sometimes futuristic architectural elements — a cocktail of the built form that immerses us into the history of the city and the people who lived there, inevitably connected to the river itself.

Indeed, it is impossible to ignore these historical urban centres and the smaller towns and villages that have developed along the banks of the river for centuries and sometimes millennia whilst looking at the Dnipro River. Hence, while the Dnipro River is, of course, at centre-stage, majestically flowing through the historical cities, it can also become a very convenient place to take a step back and observe them from the water.

Interviewing **Yehor Shtefan**

Architect
Officer in the AFU
From Kyiv

“One of my first vivid memories of the Dnipro River is from when I was a teenager. My friends and I would go ice skating there in the crisp winter and early spring. It was dangerous but thrilling. We’d end up soaked to the bone and worried our moms would scold us.I always took the time to dry my clothes thoroughly before heading home, hoping to avoid any trouble.

Another vivid memory is renting a kayak and exploring the winding tributaries of the Dnipro and Desenka rivers. Sailing along the Dnipro on a sleek yacht was incredible—gliding across the expansive river and admiring the stunning views of Kyiv. You have to try it to believe it.

When I think of the Dnipro,
I picture Kyiv and its majestic hills.
I imagine sitting on the soft sand
at Trukhaniv Island in the evening,
looking at the lights of the right
bank, St. Andrew’s Church
standing tall, and the pedestrian
bridge stretching across the water.

Those summer evenings in Kyiv, sitting by the river, had a unique and unforgettable vibe. I love witnessing nature’s extremes. I was in Venice once when the water was a meter and a half high, and I walked around the flooded city in awe. Similarly, every few years, the Dnipro floods heavily and dramatically changes the landscape.

Walking through those same
places during high water makes
you realize how powerful nature is.
Even with dams, the Dnipro River
can still assert its strength
and presence.”

2.8. Culture and heritage

2.8.1. The Dnipro River – a national symbol

"It is impossible to understand Ukraine without understanding the Dnipro — its role in forging the fortunes of the nation and its meaning to Ukraine and Ukrainians" (WP, 2024).

As Roman Cybriwsky observed in his authoritative chronicle of the Dnipro "Along Ukraine's River", rivers can "tell the story of a nation's history and a people's experience." The Dnipro River tells a tale with "a plentitude of national sorrow," he wrote, but also reveals moments "uplifting and joyous," an observation that holds true even in wartime (NYTimes, 2023). Be it uplifting or not, Ukraine's cultural history is fundamentally intertwined with the river.

For many people who live on its banks and interact with the river personally, the Dnipro River is part of their identities, but the Dnipro River is also an integral element in the collective identity of every Ukrainian through its culture value transmitted through art, literature, songs, films, the physical environment and other means of expression.

With its essential strategic, economic, and commercial significance described throughout 2. The Dnipro River as a source of life, as well as its imposing, potent, and spanning waters, the Dnipro River can not be overlooked. The Dnipro River shaped the development of societies and influenced the way people live and interact with each other. It has inspired myths and folklore, art and literature, music and films, architecture and many others, eventually becoming an inseparable part of a cultural and national identity.

Recognition comes in various forms of material and immaterial cultural representations produced throughout the centuries. In the works of artists, musicians, writers, historians, and geographers, as well as in popular culture transmitted from generation to generation, the Dnipro River acquires different meanings. But its glory and power are always recognised.

With its thousand old written and recorded history, it is rather hard to compile anything close to a comprehensive overview of the role and impact of the Dnipro River on Ukrainian culture and identity, nor is it the goal of this report. Instead, we have endeavoured below to raise some important and recurring themes and issues — exemplified by famous events and works — in an attempt to show how deeply embedded the Dnipro River has been in forming the Ukrainian culture by and large.

2.8.2. The Dnipro River as a source of inspiration: "a reverence to the Dnipro"

From the earliest times, the Dnipro River has impressed and inspired people. Passing through cities as well as the countryside, the Dnipro River is at times wide and smooth, calm and welcoming. In other areas, however, it is left to the wilderness of nature, marked by diverse vegetation and abundant wildlife among the curly riverbeds and rocky Rapids. Throughout the centuries, this diversity and grandeur of the Dnipro River have inspired many people, as seen in the many songs, poems, novels, prose, and hundreds of historical studies in various languages. The image of the Borysthenes, from the Greeks and Scythians to the times of Shevchenko, was enveloped in romance; the river was depicted through the lens of an eternal force, characterised by its roar, rumble, and noise (Dovzhenko Centre, 2023).

Figure 1. A photo of a march through the DniproHES Dam in 1990, organized by pro-independence People's Movement of Ukraine; Authors: M.Yakovenko and V.Biletskiy. Source: Wikipedia.org (Public Domain)

The Dnipro River in literature

Among the famous literary works referencing the Dnipro River we can find the baroque poem-hymn Praise of the Dnipro River [*Похвала Дніпрові*] written in the early XVIII century by the Ukrainian writer and cultural actor Theofan Prokopovych (1681-1736):

> *You are richer than all other rivers combined, perhaps,*
> *And the most famous.*
> *Your supple flow has divided the banks*
> *In such a way that an arrow*
> *Cannot traverse the entire distance between them*

Throughout the centuries the theme of the Dnipro-Slavuta was addressed repeatedly by many prominant Ukrainian writers and cultural figures. These include Maxim Rylsky, Hryhoriy Chupryna, Vasyl Symonenko, Pavlo Tychyna, Volodymyr Sosyura ("The ice has not yet crossed the Dnipro"), Mykola Vingranovsky ("Do you hear, my Dnipro", "Tell me, Dnipr", "Night of Ivan Bohun"), Oles Honchar and many others.

But, perhaps one of the most famous lines about the Dnipro River, from Ukrainian literature known to many Ukrainians is the excerpt from Mykola Hohol's work, A Terrible Vengeance (1831):

> *Beautiful is the Dnipro in calm weather, when it freely and smoothly rushes through forests and mountains, full of its waters. It neither stirs nor murmurs. You look and do not know whether its majestic breadth is moving or not, and it seems as if it is all poured from glass and like a blue mirrored path, boundlessly wide, endlessly long, flows and winds through the green world. It is pleasant then for the hot sun to look from a height and to cast its rays into the cold glassy waters, and to be brightly reflected in the coastal forests. Green-haired ones! They have fallen together with the field flowers to the water and, bending over, look at them - and they cannot look enough, and do not tire of their bright image, and smile at it, and greet it, nodding with their branches. But into the depths of the Dnipro they dare not look: no one, except the sun and the blue sky, looks there. Rarely does any bird fly to the middle of the Dnipro. Magnificent! There is no river like it in the world.*

The Dnipro River in paintings

The beauty of the Dnipro River is also depicted in many canvases by both famous and lesser-known artists from various eras and countries. Perhaps the most famous of all artistic depictions of the Dnipro are the paintings by the Ukrainian master Arkhip Kuindzhi, *Dnipro in the Morning* (1881) and *Moonlit Night on the Dnipro* (1880), but also the *Red Sunset on the Dnipro* currently displayed in the New York MET. They are easily recognisable, and their reproductions can be found in many galleries. Another famous Ukrainian painter (of Armenian origin) and a master of marine art — Ivan Ayvazovsky — depicted the river on several occasions throughout his lifetime, as seen through his works *The Reed on the Dnipro* (1857), *Ice on the Dnipro* (1872), *River of time* (1887), *Crossing the Dnipro in moonlit night* (1897).
Similarly, the image of the Dnipro River became a true source of inspiration for Ivan Trush, who returned to the Dnipro again and again throughout his creative journey, leaving behind him a legacy of about 180 works dedicated to Ukraine's mighty water artery. The Dnipro River is also featured in the works of Mykola Burachek, Mykola Murashko, Volodymyr Orlovsky, Tetiana Yablonska, and many others. To name just another familiar name, we may also mention here the famous Taras Shevchenko, who is widely known for his literary heritage but much less as a painter, despite his talent and many works. Shevchenko, too, painted the Dnipro River on several occasions during his trips to Ukraine.

Figure 2: *Dnipro in the Morning* (1881) by Arkhip Kuindzhi
Source: Accessed at Wikipedia.org (Public Domain)

Figure 3. (top left): *Red Sunset on the Dnipro* (1905-8) by Arkhip Kuindzhi
Source: Accessed at Wikipedia.org (Public Domain)

Figure 4. (bottom left): *The moon rose above the Dnipro* (1980) by Ivan Marchuk
Source: Goldens / Facebook

Figure 5. (top centre) *Dnipro River* (1904) by Jan Stanislawki
Source: Accessed at Wikipedia.org (Public Domain)

Figure 6. (centre): Kyiv from the Dnipro and other sketches (1843) by Taras Shevchenko
Source: Accessed at Wikipedia.org (Public Domain)

Figure 7. (top right): *Crossing the Dnipro in moonlit night* (1897) by Ivan Aivazovsky
Source: Accessed at Museum of Ukrainian Painting (Public Domain)

Figure 8. (bottom right): *Ice on the Dnipro* (1872) by Ivan Aivazovsky
Source: Accessed at Wikipedia.org (Public Domain)

Figure 9. (bottom centre): *Dnipro near Kyiv*, 1910 by Ivan Trush
Source: Accessed at Artes Almanac (Public Domain)

2.8.3. The lost and preserved heritage of the Dnipro River

In ancient myths, legends and historical manuscripts

Depicted in Shevchenko's drawings and described in the many poems and manuscripts, inseparable from the Dnipro River is, of course, Ukraine's historical capital and largest city — Kyiv. Situated on the right bank of the river, between a busy highway and the riverside promenade, spears belonging to brothers Kyi, Schek, Horyv and their sister Lybid poke out above the grey boarding and some sandbags that protect the monument celebrating the founding of Kyiv from Russian missile attacks.

According to the popular legend, the siblings, who are shown arriving by boat from the north, founded Kyiv on the shores of the Dnipro River in the 6th century (Washington Post, 2024). A legend it is, yet mentions of the Dnipro River can indeed be found in the major historical manuscripts of the Kyivian Rus, dating back to the XII century. Most famously, the centrality of the Dnipro River is reflected in the Primary Chronicle and the epic poem The Tale of Ihor's Campaign, where the Dnipro is poetically referred to as Slavutych — meaning the Slavic river, or, alternatively, the glorious river. For the whole orthodox Christian world, since the times of the prince Volodymyr the Great, the Dnipro River is also a prominent symbol of the Christianisation of Rus (988). An event depicted in the painting of Volodymyr Slepchenko hanging on the walls of Kyiv's Saint Sophia Cathedral, but also reflected in the religious tradition of Vodokhreshche, plunging into the cold waters of the river every January. Indeed, throughout the centuries, the Dnipro River preserved its deep cultural — if not sacral — role both for the many individual people connected to it and also for the idea of a 'Ukrainian' statehood.

Figure 10: Photo of the Monument of the Founders of Kyiv before the full-scale invasion
Author: unknwon; Source: Balbek Bureau

Figure 11: Photo of the Monument of the Founders of Kyiv protected from missile and drone attacks
Author: Slava Balbek; Source: Balbek Bureau

In sculpture and architecture

Of course, with its length of almost a thousand km flowing through the territory of modern-day Ukraine, the Dnipro River extends far beyond Kyiv, crossing through forest and steppe, meandering between the hills and and the rocks, and passing though cities as well as villages until its river delta finally flows into the Black sea.

Throughout Ukraine, each of the many cities, towns and villages that sit by the river preserve their own collective memory and view of the Dnipro River as an inseparable element of the life of the people on its banks. The importance of the Dnipro River for these communities is sometimes reflected materially, physically and visually on the coats of arms inherited from the past or, for instance, through architectural details and styles preserved on historical buildings, such as the ornaments and mosaics of the Kyiv River Port building.

Figure 12: Ornaments representing riverine elements related to the Dnipro River on the facade of the Kyiv River Port
Author: Stepan Nazarov; Source: Your Art (https://supportyourart.com)

Figure 13: Mosaic of ancient boats on the Dnipro River inside the Kyiv River Port
Author: Stepan Nazarov; Source: Your Art (https://supportyourart.com)

In collective memory

Perhaps, more importantly, the Dnipro River's immaterial and intangible side is reflected in the identities of the people who live in those many cities and villages. This connection is not always as straightforward. However, it undoubtedly shapes the way people live and interact with the River and with each other and is central to their sense of belonging. Unfortunately, the immense value of this intangible cultural significance can sometimes be revealed due to not the most favourable events. This was definitely the case for the thousands of people living in the many villages that have been lost and erased from the maps as a consequence of the construction of the Dnipro Cascade of reservoirs in the 1930s and 1950s-70s (see 1.2. Historical overview). In the mid-1960s, soil scientist Viktor Kovda estimated that around 2,500 villages and 156 towns ended up at the bottom of artificial reservoirs, while approximately 3 million residents were displaced from their centuries-old settlements (The Village Ukraine, 2023). More recent research published by Texty was able to identify a lower, albeit still impressive, total number of 232 villages (only those recorded on maps) across the six Dnipro River Reservoirs that were entirely or partially flooded (Texty, 2024).

Figure 14. Ruins of the Saint Illia Church in the village of Tsybli, flooded during the creation of the Kaniv reservoir (Kyiv region), 2020. Source: Dovkola Media, https://dovkola.media

The creation of the reservoirs resulted in the loss of thousands of hectares of land, including many historical landscapes, such as, for instance, the Dnipro Rapids (discussed above in 1.2. Historical overview & 2.7. Tourism and recreation) and many cultural objects, including cemeteries, houses, churches, fortresses, most of which were destroyed before their planned flooding, in order not to obstruct navigation.

Most importantly, however, the waters of the reservoirs took with them the immaterial rural Ukrainian culture, as well as the memory of the Cossack times. Along with legends and stories, a rich Cossack toponymy was lost, with old names of villages, places, streams and rivers disappearing forever, together with the many local residents of the bank-side villages that carried a whole layer of folklore (Texty, 2023a). Many in Ukraine are still persuaded that in addition to purely pragmatic goals such as providing navigation, electricity and water supply for agriculture and the population, the creation of the Kakhovka and the other reservoirs had another goal: erasing the national memory of Ukrainians through the deliberate destruction of both material and immaterial culture (Texty, 2023b).

Figure 15. An ancient Cossack cross on the banks of the Dnipro River near the flooded village of Tsybli (Kyiv region), 2020. Source: Dovkola Media, https://dovkola.media

As the Dnipro Rapids and the many villages were submerged underwater, together with precious immaterial culture, some people refused to leave their origins behind. In 2015, an NGO called “Old Dnipro” was founded by the former inhabitants with the aim of uniting the efforts of concerned citizens and displaced persons from areas flooded by the Dnipro reservoirs to restore and preserve the memory of the submerged lands, the people and their families who formed local communities, and the values that guided these people in their lives. The community collects historical information and stories of witnesses, publishes books and organises cultural events.

One of them is the yearly “Dnipro Roaring” swim, which the organisers see as much more than a swim but a patriotic upbringing; it is an act of historical preservation (Ukraïner, 2021). In Andrushi, The Open Air Museum has organised meetings of residents of the sunken villages of the Pereyaslav region since 2010 on the temple holiday. Migrants from all over Ukraine came to these meetings, exchanging memories and stories (Ukraïner, 2021). Thanks to old maps and paintings, photos, videos, today we can see local landscapes and architectural monuments destroyed or flooded during the construction of the dams.

But the memory of the Dnipro River also lives as long as people carry it. As an article by Ukraïner noted: “The preservation of the memory of sunken villages is a matter of honour for every Ukrainian when it comes to the territories that took part in the process of state formation from ancient times to the present” (Ukraïner, 2021).

In films and photography

Back in the days when the Soviet regime was destroying those very villages, prominent Ukrainian cultural actors also fought to preserve the memory of these historical places for the next generations. Well-known Ukrainian directors came to shoot scenes for their films in the areas of the Kaniv Reservoir. For instance, the village of Tsybli before the flood can be seen in the film “Trust” by Mykola Ilyinskyi (Ukrainer, 2021). The power of cinematography and photography allowed us to preserve those old images of the Dnipro River throughout the 20th century.

During his expedition to the Dnipro Rapids in 1927, when the construction of the Dnipro-HES was just starting, the famous ethnographer and historian of the Cossack times, Dmytro Yavornytskyy, wrote to the archaeologist Mykhailo Rudnytskiy: “I feel so eerie at the thought of the future works on the Dnipro […] In my opinion […] First and foremost, we should document the rapids as they currently exist. We need to extensively use cinematography to capture the nature of Zaporizhzhia and its way of life. We must document our pilots and the entire lives of people connected with the rapids. Finally, we should take the opportunity to “film,” as cinematographers say, a whole series of scenes from history, a whole series of scenes from the life of Zaporizhzhia. So, we need to start something while the rapids are still alive” (Local History, 2023).

In the years that followed, artists from around the country, including Dzyga Vertov, Yevhen Makarov, Oleksandr Dovzhenko, Ivan Kavaleridze, Arnold Kordyum, and Yuliya Solntseva came to document this gigantic construction. While many of them were impressed by the new Hydroelectric power station and portrayed it in a positive light, coexisting with the river, some also understood and highlighted the various social and environmental consequences of this Soviet megalomaniac project. Footage of the Dnipro Rapids before they were flooded was produced by the VUFKU cinematographers “for all those citizens who will read the history of Ukraine and will not be able to see the rapids with their own eyes.” In 1927, Dzyga Vertov, along with cameramen Mikhail Kaufman and Boris Tseitlin, in the course of filming “The Eleventh Year,” showcased the very same rapids, villages, and the Scythian skeleton discovered during excavations at the construction site (Dovzhenko Centre, 2023).

Another cinematographer — Arnold Kordyum, also captured the River and the construction in his adventure film “Wind from the Rapids” (1929) and the documentary “Dnipro in Concrete” (1930). Ivan Kavaleridze, too, expressed the scale of the construction in his last silent film “Stormy Nights” (1931), which was eventually banned from screening for being “politically harmful.”

Perhaps Ukraine's most famous filmmaker — Oleksandr Dovzhenko — was too impressed by the construction and abandoned his large-scale project about the Arctic to address the topic of the Dnipro construction and the associated social conflicts in his first sound film "Ivan" (1932) (Dovzhenko Centre, 2023). A few decades later, Dovzhenko also did not ignore the construction of the Kakhovka Hydroelectric Power Station (1956), which eventually flooded the historical Great Meadow.

he preparation of the script for his cinematic ode started in 1951, almost concurrently with the start of the construction. The work was initially titled "Transformers of the Steppes" and later "The Sea" before it was finally renamed to "The Poem of the Sea" (1958). The documentary footage recorded the construction of the hydroelectric station, "Sirko's grave," and landscapes seen for the last time. The film was completed by Dovzhenko's widow, Yulia Solntseva, after the director's death (Dovzhenko Centre, 2023).

In one of his notebooks, Dovzhenko wrote: "I love Nova Kakhovka. I love the Dnipro—the great river of my people, the clean, gentle air, the clear sky, and the expansiveness in everything. Both the restraint in the landscape and the majestic tranquillity." Like many other documentary and feature films, as well as photographs and other recorded materials, their cultural heritage continues to define the importance of the Dnipro River today and helps to revive the memory of those villages. In a sense, they represented a form of battle against the totalitarian machine by allowing those different elements of landscape and human settlements to live on.

Figure 16: Frame from the film 'Poem of the Sea' (1958, directed by Y. Solntseva). From the collection of the Dovzhenko Center Film Archive.

Figure 17: Frame from the film 'Poem of the Sea' (1958, directed by Y. Solntseva). From the collection of the Dovzhenko Center Film Archive.

2.8.4. The Dnipro River and the struggle again russian oppression

Undoubtedly, the idea of resistance and struggle is a recurring theme in Ukrainian culture. It can be seen through the many historical events and battles that occurred throughout history, in the way of life and also in the art. In talking about this overarching theme in Ukrainian culture and the history of the struggle against foreign oppression, it is impossible to miss one name above all — that of the famous Ukrainian writer Taras Shevchenko. As it happens, the topic of struggle, central to his work, also very often comes back to the symbolic, but at the same time quite a literal image of the Dnipro River. In fact, the Dnipro River is recurring throughout all of Shevchenko's literary works.

While his earlier poems, like the ballad *"The Bewitched" ["Prychynna"]* (1837), offer a more poetic, more romantic description of the Dnipro, his later works delve into the context of a personal and national struggle against imperial Russian oppression. His poem *"The Testament" ["Zapovit"]* will become one of his most popular works, calling the Ukrainian people for a liberation struggle, and having a significant impact on Ukrainian culture. Symbolically, written in 1845, the poem was completed in V'yunyshche, a village that since the erection of the Kaniv HES has been flooded, submerged under the waters of the Kaniv Reservoir.

[1] "Bewitched" ["Причинна"] (1837), Taras Shevchenko; Translated by Vera Rich; Accessed at https://taras-shevchenko.storinka.org.

[2] "And I grew up in foreign land" ["І виріс я на чужині"] (1848), Taras Shevcehnko; Translated (literal) by Antoine Korchagin.

[3] "To my fellow-countrymen, in Ukraine and not in Ukraine, living, dead and as yet unborn my friendly epistle" ["І мертвим і мертвим, і живим, і ненародженним..."] (1845), Taras Shevchenko; Translated by Vera Rich.

[4] "Testament" ["Заповіт"] (1845), Taras Shevchenko; Translated by John Weir.

> *Roaring and groaning rolls the Dnipro,*
> *An angry wind howls through the night,*
> *Bowing and bending the high willows,*
> *And raising waves to mountain heights.*[1]

> *And I grew up in foreign land,*
> *And graying am in foreign land:*
> *It seems to me, lonely as I am,*
> *That there's nothing better*
> *Than God's gift of the Dnipro*
> *And our glorious country ...*[2]

> *Look upon your native country,*
> *On this peaceful eden;*
> *Love with overflowing heart*
> *This expanse of ruin!*
> *Break your chains, and live as brothers!*
> *Do not try to seek,*
> *Do not ask in foreign lands*
> *For what can never be*
> *Even in heaven, let alone*
> *In a foreign region...*
> *In one's own house,— one's own truth,*
> *One's own might and freedom.*
> *There is no other Ukraine,*
> *No second Dnipro in the world …*[3]

> *When I am dead, bury me*
> *In my belo`ved Ukraine,*
> *My tomb upon a grave mound high*
> *Amid the spreading plain,*
>
> *So that the fields, the boundless steppes,*
> *The Dnipro's plunging shore*
> *My eyes could see, my ears could hear*
> *The mighty river roar.*
>
> *When from Ukraine the Dnipro bears*
> *Into the deep blue sea*
> *The blood of foes ... then will I leave*
> *These hills and fertile fields ...* [4]

This recurring theme is reflected in Ivan Nechuy-Levytsky's *"Night on the Dnipro"* (1883), a classic example of Ukrainian literature, characterized by a deep sense of patriotism and the struggle against external threats, through the depiction of Cossack life on the banks of the Dnipro River — a central highlight of Ukrainian history and culture. This symbolism of the Dnipro River has also been preserved in the 20th century, for instance, in the work of the famous Ukrainian poet Oleksandr Oles — *"Dnipro, Dnipro…".*

Most famously of all, the Dnipro River is mentioned in the national anthem of Ukraine "Ukraine has not yet perished" (1865), written by Pavlo Chubynsky. The words of the anthem reveal this unique connection between the theme of a national resistance struggle for freedom and independence, and the Dnipro River.

Today, amid the russian full scale war against Ukraine, disasters such as that of the russian terrorist destruction of the Kakhovka Dam, resulting in significant damage to the environment and the economy also become part of a recorded history of the Dnipro River, embedded into the collective memory and the cultural identity of Ukrainians for generations to come.

[5] "Dnipro, Dnipro..." ["Дніпро, Дніпро..."], Oleksandr Oles; Translated (literal) by Antoine Korchagin.

[6] The national anthem of Ukraine – "Shche ne vmerla Ukraina" ["Ще не вмерла Україна"] (1865), Pavlo Chubynsky. Translation accessed at Wikipedia.org.

> *Long ago, in times of war,*
> *You walked with the Cossacks,*
> *Carried their boats on your shoulders,*
> *Hid them among the reeds.[...]*
>
> *Dnipro! Whoever has seen you once,*
> *Will never forget you.*
> *You are as free as an eagle,*
> *Not bound in chains.[...]*
>
> *And again, mighty, you call*
> *To fight for freedom,*
> *And your waves already soar,*
> *Roar, bellow across the field.*[5]

> *Ukraine's freedom has not yet perished,*
> *nor has her glory,*
> *Upon us, fellow Ukrainians,*
> *fate shall smile once more. […]*
>
> *Brethren, stand together in a bloody fight,*
> *from the Sian to the Don*
> *We will not allow others to rule*
> *in our native land.*
>
> *The Black Sea will smile*
> *and grandfather Dnipro will rejoice,*
> *For in our own Ukraine*
> *fortune shall flourish again.*[6]

2.8.5. Dnipro divides. Dnipro Unites.

Throughout the centuries, the Dnipro River has marked the limits of various kingdoms, empires, states and peoples. This division can be noticed in some of the examples discussed above, for it remained deeply embedded into political, cultural, and identity narratives that have transcended throughout the centuries and into modern times.

The blue line of the Dnipro is often seen as the line dividing the Ukrainian globe into two hemispheres — an eastern and a western one.

In other words – a European Ukraine and a Russian one. This idea is reflected in Mykola Riabchuk's idea of 'two Ukraines', which transcends the physical geographical and cartographical landscape of left bank versus right bank semantics into a mental landscape characterised by opposing and competing identity projects (Riabchuk, 1992).

In modern times, this collision of identities has been manifested eloquently in the "dramatic split of the country and people's loyalties between the proverbial 'East' and 'West', between the 'Eurasian' and 'European' ways of development epitomised by Russia and the European Union". With Europe to the west and Russia to the east, Ukraine's identity and geography are united and divided by the Dnipro. Ukrainians understand their demography by referencing the river's left and right banks, the right to the west and the left to the east looking downstream. (WP, 2024). In his works, Andrukhovych portrays this very split and conflict as constituting "the core of Ukraine's historical challenge" from time immemorial (Andrukhovych, 2007, p.125).

The separating force of the Dnipro river is evident (and probably inevitable), and yet at the same time, Andrukhovych's division of Ukraine through the description of its landscapes (plains, steppes, forests, hills, 'wild field') that stretch along both of the Dnipro's banks bring doubts into whether any feature of the landscape can constitute a genuine border. "In the essay' Poltava, 2007' (2007) from the volume Lexicon of Intimate Cities, Andrukhovych proposed to see the Dnipro as a unifying principle through the mythological conceptualisation of topological components as parts of a living being.

Here, the Dnipro River is the backbone that unites the left bank with the right bank as parts of a single living body with its heart somewhere in Poltava (Andrukhovych, 2016, p.332).

This metaphor recognises the historical connection of the right and left bank as a place with distinct yet common cultural and political identities that developed not in parallel to each other but in connection to one another.

Today, in 2024, as Ukrainians from all across the country unite together to oppose the russian war of aggression, the image of a Ukraine detached along the Dnipro River seems all the more irrelevant, perhaps to some extent offensive, if not simply ignorant. In retrospect, however, the complexity of Ukrainian history mixed with different values and levels of historical awareness, as well as with the ambiguity and bias of select cultural, historical, political, anthropological, aesthetic and sometimes even mythological interpretations, understandably produce a "semantically multi-charged image of the Dnipro".

As Spodarets concludes in her paper "One River. Two Ukraines": "the image of the Dnipro can be interpreted as a symbol of a landscape border or the backbone of the Ukrainian state body; it can metonymically be seen as a dividing trope for Ukrainian dichotomies or a symbol of the country's European identity". In other words, the image of the Dnipro can include the meaning both of "a boundary as well as an overcoming of this boundary", for "geographically, the river divides the land, but at the same time it keeps it together by creating a continuous memory flow" (Sporadets, 2017, p.57).

In his book "Along Ukraine's River: A Social and Environmental History of the Dnipro", Cybriwsky (2018) interestingly concludes that the Dnipro River is not only a natural object, but also, perhaps more importantly, a cultural and historical phenomenon containing symbolic meaning and playing a significant role in the nation-building process. Indeed, whether in dividing or uniting the people that have historically inhibited its banks, in physical, social or cultural terms, one thing is undubitable – the Dnipro River retains its defining role in Ukrainian culture and identity. Ultimately, everyone is free to interpret the Dnipro River as prefer. The famous contemporary Ukrainian writer, poet, and now a soldier of the Ukrainian Armed Forces Serhii Zhadan gives a compelling way to look at it (WP, 2024):

I always felt like a left-bank Ukrainian. This is not an opposition to the right bank, but it is an understanding that the Dnipro River is such a great metaphor, a great emblem, which seems to divide Ukraine, but actually unites it".

Part 3
Life under threat: the Dnipro River under attack

Contents

Summary

The way we interacted with the Dnipro River in the past had been far from exemplary. Unfortunately, this trend persists into the present day. The 2014 russian annexation of Crimea and, in particular, its full-scale invasion since 2022 turned the river Dnipro River into a focal point of vulnerability, revealing the many challenges that it faces. Of course, russian attacks have directly threatened the river's integrity, with invading troops swiftly crossing its waters during offensive manoeuvers but also using its water and banks as a convenient military frontline. As in history, the Dnipro River has again been weaponised, becoming an element of warfare, a tool, and a target, as best exemplified by the russian terrorist destruction of the Kakhovka Dam in 2023. Of course, the military consequences of the war are devastating both for the human and the natural environments, as both human settlements and ecosystems are destroyed or damaged.

While some fundamental issues regarding the river's management were known and recognised beforehand, the exigencies of war have revealed and highlighted long-ignored limitations and vulnerabilities, the roots of which often extend much further back in time. Today, the river faces a multifaceted risk, not only from direct military aggression but also from broader anthropocentric and resource-intensive practices that have depleted its natural resilience. Human waste discharged into the river, whether from agricultural pesticides, industrial pollutants, or untreated household waste, poses serious threats and concerns not only to the health of our ecosystems but also to our health, as humans and as societies. These challenges have immediate impacts on our social and economic well-being, but they also have significant and long-lasting impacts amid rising concerns about climate change, water scarcity, and natural disasters. As a source of life and livelihood for countless communities, the Dnipro River begs the question: How much further can we afford to undermine its health and vitality?

3.1. The Dnipro River as a frontline

3.1.1. Russia's war against Ukraine

In the early hours of the invasion, russian forces crossed the Dnipro and camped on both sides of Ukraine's main strategic, economic and cultural artery for nearly nine months. With the Ukrainian counteroffensive in the Autumn of 2022, the russian army was cornered and eventually forced to retreat across the river to the east. Since then, the natural flow of the Dnipro River has become the main frontline in southern Ukraine, with the east bank still largely held by russia (WP, 2024). Now, the two armies face each other on either bank across approximately 300 km, spanning from Kamianske (Zaporizhzhia oblast) to the Dnipro Estuary and the Black Sea.

The Ukrainian liberation of its 'right bank territories' after eight months of brutal occupation was a euphoric victory and a key moment in Ukraine's war effort, but the time since has brought little relief. The russian forces have since fortified their positions along the river by building extensive defence lines and trenches (Le Monde, 2023) while continuing to strike military and civilian targets on territories controlled by Ukraine. Kherson city and its surrounding region remain under relentless bombardment by russian forces across the river (CNN, 2023). As the NYT journalists expressively put it, "The thunder of artillery echoes night and day over the mighty Dnipro River as it winds its way through southern Ukraine. With russian and Ukrainian forces squared off on opposite banks, fighters have replaced fishermen, surveillance drones circle overhead, and mines line the marshy embankments" (NYTimes, 2023).

As the war rages along the river, constant bombardments target strategic sites and communication routes, but russia also often directs its fire at residential and civilian areas, scarring towns and villages. Buildings close to the river's edge are hit repeatedly by russian drone and missile attacks, artillery, but also tanks and snipers. According to Oleksandr Tolokonnikov, a spokesman for Kherson's regional military administration, between 30 to 100 munitions land in the city every day (WP, 2024).

Since late 2022, Ukrainian forces conducted a series of raids across the river. Some of them were successful, as several units seem to have strengthened their positions on the left bank, claiming a foothold in the village of Krynky, east of Nova Kakhovka. However, securing a crossing over the Dnipro River is a challenging task. At some points stretching up to a mile in width, the Dnipro River serves as a natural defensive barrier for russian troops and is regarded as one of the keydefensive assets. In general, river crossings are among the most complex and dangerous military operations. The Dnipro River is too, and history can only confirm this (France24, 2023).

Figure 1. Screenshot from an infographical publication shows the Dnipro River in the Kherson region, separating areas controlled by Ukraine from those occupied by the russian armed forces (in red). Author: LeMonde.fr, March 2023.

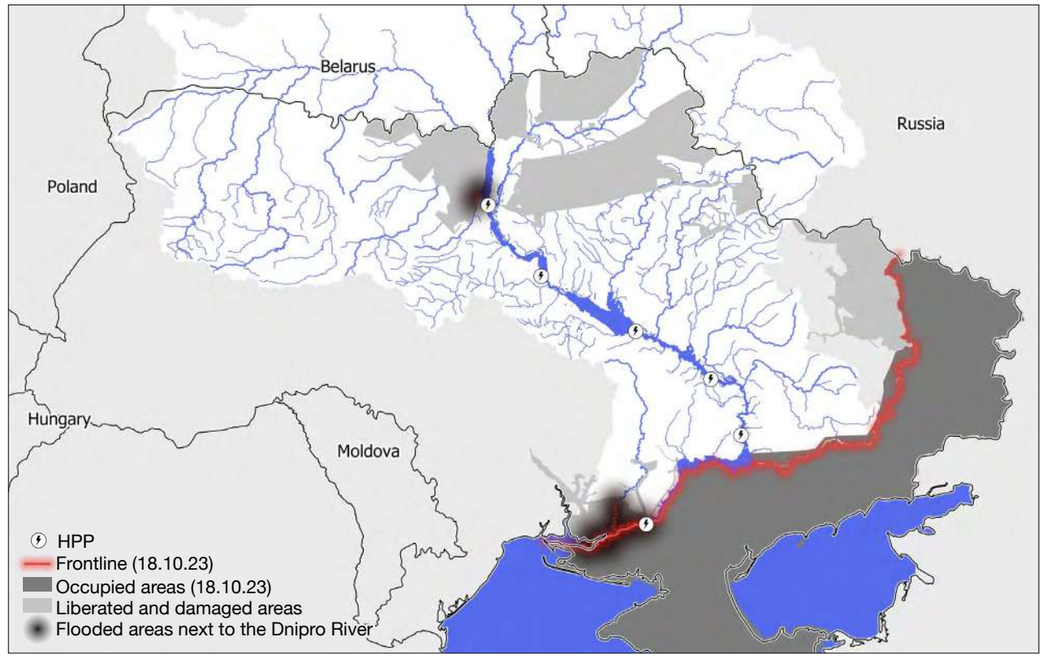


Figure 2. Map of the Dnipro River basin in Ukraine and the areas affected by the russian military invasion, as of October 2023. The frontline is seen following the Dnipro River in the southern regions, where most of the damage to the river can be observed. Author: Elaborated by Ro3kvit and Greenpeace CEE.

Interviewing **Yehor Shtefan**

Architect
Officer in the
Armed Forces of Ukraine
From Kyiv

In my current practice, the Dnipro River and its proximity pose a deadly danger. It serves as the main combat line in my direction.

On one hand, it's a significant barrier for the enemy, who can't easily send sabotage groups, so we feel relatively safe on the right bank. On the other hand, we aim to de-occupy the left bank, which presents a significant challenge.

From a tactical and strategic point of view, the Dnipro River is a serious obstacle. We suffer many losses because we have to supply forces on the left bank's bridgehead with food, ammunition, and personnel, and evacuate the wounded and dead. Crossing the Dnipro by boat is highly dangerous.

The closer you are to the river, the more perilous it becomes, so we try to stay away from it. When you're in direct sight of the left bank, you're in immediate danger, especially if you're on transport. You can be hit by a mortar or an anti-tank guided missile, and some of my comrades have been wounded for getting too close to the Dnipro River.

The future of the river depends on the outcome of the war. If we manage to liberate significant territory on the left bank and push the enemy back, we can restore the Dnipro River as a vital transportation artery and a major recreational area for our country. If we fail, it will remain a tense border between us and the enemy, with all the corresponding consequences.

There are no clear answers about the future right now. We need to shape what happens next. Once we understand how the battlefield and the political situation in Russia evolve, we can talk about the future of the Dnipro River.

In a peaceful postwar life, the Dnipro River is the most important place in Ukraine and our most significant natural landmark.

Figure 3. Soldiers of the Armed Forces of Ukraine on the Dnipro River in southern Ukraine, February 2024
Author: 35 ОБРМП ім. М.Остроградського; Source: ArmyInform

3.1.2. A historical perspective: The Second World War and the Battle for the Dnipro (1943)

As russian occupying forces and Ukrainian defenders are facing each other along the river, the Dnipro River naturally helps to define the contours of the battle — as it has for millenniums, a barrier and a conduit to warring Scythians, Greeks, Vikings, Huns, Cossacks, russians, Germans and many more" (NYTimes, 2023). Indeed, due to its strategic geographical and political position, Ukraine has often been the area of devastating wars and large-scale military battles. Since the Middle Ages and into modern times, many battles have been fought on the banks of the Dnipro River. The most memorable for both its scale and violence is undoubtedly the Battle for the Dnipro (1943) during the Second World War. Some 80 years ago, on November 6, 1943, Soviet troops, overcoming German resistance, entered into Kyiv. The Battle for Kyiv was one of the key episodes of the much larger Battle for the Dnipro, which lasted from late summer until the end River of December 1943 (Radio Svoboda, 2023). When it became clear that Germany started to lose momentum on the Eastern front and had to retreat, Hitler ordered the construction of a sophisticated defensive fortification line known as the Panther-Wotan line or *Ostwall*. The line stretched all the way from Narva and the Baltic Sea towards the Black and Azov Seas in the south, with a large portion of it running precisely along the Dnipro River. Strengthening positions along the Dnipro River was no coincidence but a logical strategic decision as the high terrains of the right bank dominated over the left bank plains, and the river itself provided a natural defensive line for the advancing Soviet counteroffensive (UA Info, 2018). In Ukrainian (and world) history, The Battle of the Dnipro River can confidently be named one of the largest military operations. The frontline stretched approximately 1,400 km, and about four million people from both sides were involved in the fighting. The Soviets had both numerical and technological advantages: 2,650,000 soldiers compared to 1,240,000 Germans (Artefact, 2018). With a total number of casualties ranging from 1 to 2.7 million people, it is also, evidently, one of the bloodiest (UA Info, 2018). According to official statistics, approximately 283,000 German military personnel were killed and another 800,000 wounded, while the Red Army lost 417,000 soldiers dead and over 1.2 million wounded. Among historians, however, the prevailing opinion is that the number of casualties on the Soviet side was even higher, ranging from 800,000 (Radio Svoboda, 2023; Artefact, 2018). The well-known Soviet writer and frontline soldier Viktor Astafyev, who forced the Dnipro River in the Bukryn Bridgehead south of Kyiv, recalled: "When 25,000 soldiers entered the Dnipro from one side, no more than 5-6 thousand came out on the opposite side […] The river turned crimson in colour, and its water tasted salty. Thousands of corpses floated here and there" (Artefact, 2018). Eventually, Soviet troops (among which millions of Ukrainians, mobilised and not trained) overcame German defences, however, the losses while forcing the Dnipro River were colossal (Radio Svoboda, 2023).

Figure 5. German soldiers preparing for the Soviet counteroffensive in the Battle of the Dnipro, Lower Dnipro (1943). Author: unknown; Accessed via: Wikipedia.org (Public Domain)

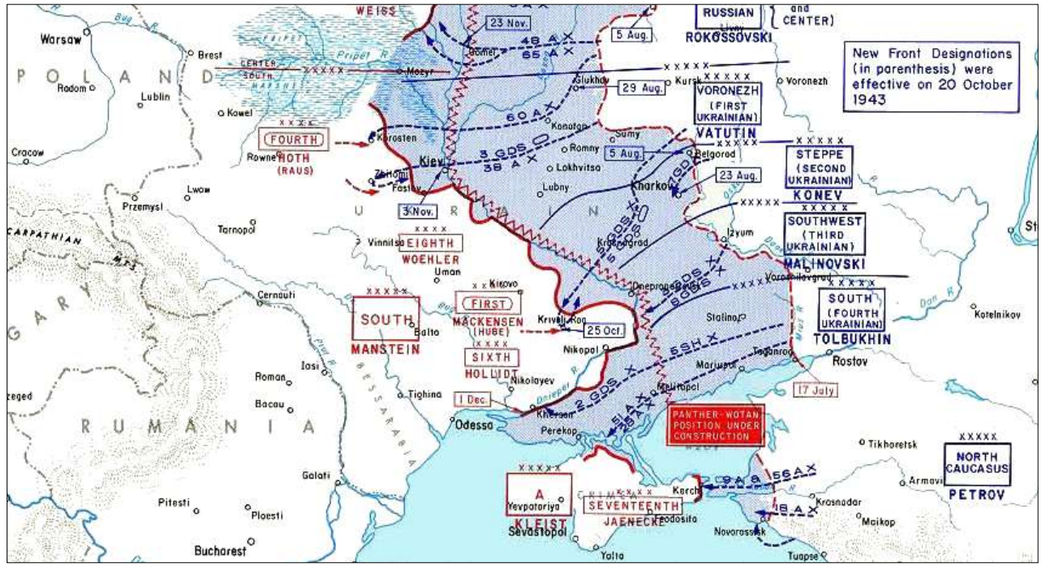


Figure 6. An exerpt of a map of the Battle for the Dnipro and connected operations in 1943: the frontline follows the Dnipro River. Author: unknown; Accessed via: Wikipedia.org (Public Domain)

3.1.3. The weaponisation of water: a military rationale behind the Dnipro Cascade?

The Dnipro River, a vital lifeline in Eastern Europe, played indeed a significant strategic role during the Second World War. Its vast expanse and crucial geographic positioning made it a focal point for military operations, where both Axis and Allied forces sought to control and utilise its waters for transportation, defense, and as a natural barrier. While the Dnipro River was used for conventional military operations, it also became a tool for tactical flooding and infrastructure sabotage, aiming to hinder enemy advancements and reshape battlefronts.

During the war, water becomes both a target and a weapon.

In 1941, as German troops swept through Soviet-era Ukraine, Josef Stalin's secret police blew up the Dnipro HES dam in the southern city of Zaporizhzhia to slow the Nazi advance. The explosion flooded villages along the banks of the Dnipro River, killing thousands of civilians (Radio Free Europe, 2013). While we will never know the exact number of casualties, it is likely that the estimation of 3,000 victims is closer to the truth than the 80,000 or 100,000 often quoted (Radio Svoboda, 2023). During the Nazi occupation, the dam was rebuilt and partly in operation, but already in 1943, as the Germans had to retreat from the Soviet counteroffensive, the DniproHES was mined again, and a part of it was blown up. These repeated attacks clearly show just how meaningful the dams and the reservoirs were for military strategy, transforming the water from the large water reservoirs into weapons of human warfare.

As described in section 1.2. Historical overview the decades after the Second World War saw not only the reconstruction of the DniproHES but the construction of another five dams along the Dnipro River on the territory of Ukraine. Apart from the declared objectives and motivations (discussed in detail in previous sections), such as water supply, energy generation, navigation, and irrigation, the construction of the Dnipro Cascade also had a more undisclosed, yet not less convincing, aspect. If the economic significance was always loudly advertised, its military importance was hidden under the classification "top secret." But, while never publicly admitted, the role of the Dnipro River, its waters and the surrounding landscape for military goals is unmistakable.

While the leadership of the USSR never abandoned its propagandist 'dreams' of a triumphant tank march to the English Channel, the bitter experience of the Second World War, forcing the Red Army to retreat all the way to the Volga River, reminded of the need to be prepared (Texty, 2023). Here again, the Dnipro River naturally emerged as a critical strategic asset. For the potential scenario of an invasion from the West, the Cascade of the dams, if blown up, would trigger a domino effect, creating a huge impassable water barrier (Texty, 2023). The various examples from the past, as exemplified by the DniproHES above, but also many other cases around the world (see, for instance, the British Operation 'Chastise' or the 'Dambusters Raid' destroying three dams in the German Ruhr valley in 1943) are illustrative of the practice of weaponising water and its massive infrastructure.

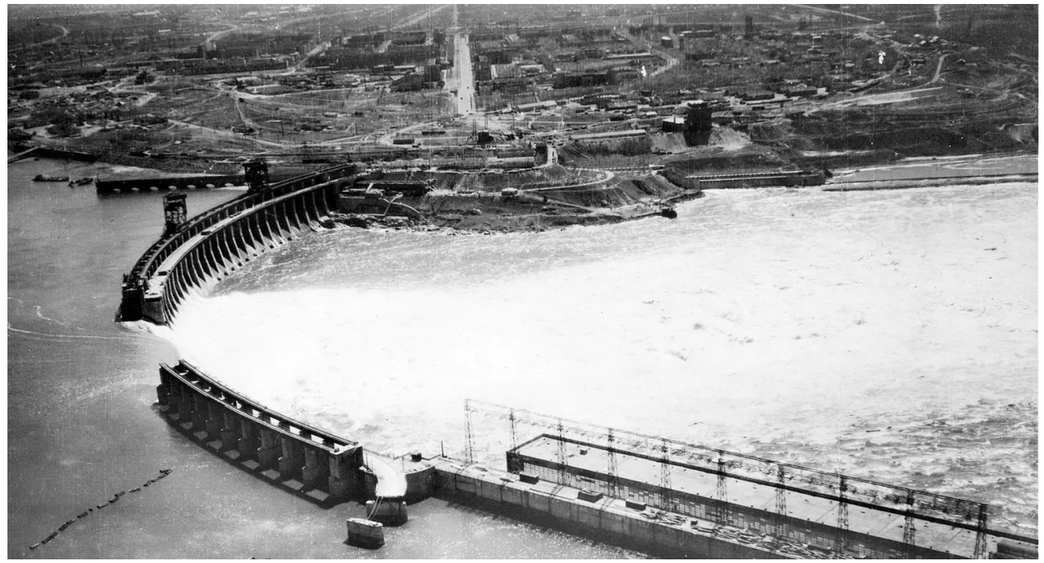


Figure 7. A photo of the DniproHES in 1941, after the Soviets destroyed while retreating from Zaporizhzhia. Author unknown; Source: Запорізький обласний краєзнавчий музей

Figure 8. A german aerial photograph of the DniproHES in 1943, after the dam was again partly destroyed by the retreating Nazi German forces. Author: unknown; Source: Запорізький обласний краєзнавчий музей

3.1.4. The persisting threat as the new reality

The most recent examples during russia's ongoing war against Ukraine only confirm this tradition of weaponisation. Just three days after the start of the full-scale invasion in February 2022, russian forces destroyed a dam in Ukraine's Kherson region that had blocked water access to Crimea, illegally occupied by russia since 2014 (Reuters, 2022; Politico, 2022).

Since then, numerous dams have been targeted and destroyed by the russian army, including, among others, the Karlivska dam and in the Donetsk region, the dam near Novodarivka in the Zaporizhzhia region, but most importantly by the scale and damage inflicted — the Kakhovka dam of the Dnipro Cascade (discussed in detail below in 3.3. Kakhovka dam destruction).

At the same time, Ukrainian forces too have blown up a dam across the Irpin River north of Kyiv in the early days of the russian invasion, flooding the entire village of Demydiv but successfully stopping the russian advance on the capital (Adam, 2023; Reuters, 2022).

"Indeed, the russian invasion of Ukraine illustrates that water weaponization continues to occur at the state level. Since the 2022 invasion, numerous instances of water contamination, destruction of ecosystem services, and targeting of water infrastructure have occurred – limiting water availability that is essential for basic survival, as well as Ukrainian agriculture and energy systems" (CCS, 2023).

These recent examples, but also those from the past, reveal just how important it is to consider and take into account the military significance of water and the rationale behind the construction of water-related infrastructure, as well as to realise the potential threats and risk related to the weaponisation of rivers. In particular, of the Dnipro River, which remains the largest and most important water artery of Ukraine.

3.2. Energy insecurity

3.2.1. Ukraine's energy sector under attack

With its economy, energy and trade deeply linked to and dependent on russia and its fossil fuels, Ukraine faced numerous challenges in the energy sector since its independence in 1991, throughout the 2000s and increasingly since the 2014 Euromaidan Revolution, as the weaponisation of gas and oil became a common instrument in russia's hybrid warfare toolkit. The availability of heat and electricity for Ukrainian consumers has depended on the decisions of the Kremlin and the attractiveness of Ukraine's domestic and foreign policy to the russian authorities. In the same way as russia has persisted with its constant energy blackmail and pressure against Ukraine, it now uses the same leverage to influence European countries that provide extensive humanitarian and military support to Ukraine in the war. However, since the beginning of russia's full-scale military invasion of Ukraine that started on February 24th 2022, the situation has taken a different dimension as Ukraine's energy sector has been on the frontline of the war, suffering unprecedented direct physical damage.

Since the early days of the war, russia has deliberately targeted energy facilities, launching massive airstrike campaigns against Ukraine's power infrastructure. Throughout the autumn of 2022, russia primarily targeted power generation and transmission facilities across the country, resulting in the destruction or damage of more than 50% of Ukraine's power infrastructure, according to the World Bank (IEA, 2024). For instance, missile attacks decimated the entire 750 kV high-voltage network that was used to distribute electricity from nuclear power plants throughout Ukraine (Wilson Centre, 2024). In October 2022, Ukraine's energy minister reported that some 30% of Ukraine's Energy infrastructure appeared to have been attacked in a single day. As temperatures have dropped, extensive damage to the energy network left millions of Ukrainians across the country without reliable supplies of electricity or heat for long periods, resulting in blackouts, including in the capital city, Kyiv.

In June 2023, the UNDP Energy Damage Assessment reported that "in total, over 90% of wind generation, about 75% of thermal generation, almost half of the nuclear generation, over 30% of solar generation have been damaged or are in the territories outside of the government control during the war" (UNDP, 2023). Already in April of the same year, there was not a single Thermal or Hydro Power Plant that was not damaged to some extent due to military activities and missile attacks (IEA, 2024; Energy Charter, 2023). Available capacity has decreased from 37.6 GW in early 2022 to 18.3 GW at the end of April, as, among others, thermal power capacities were reduced by 65% (from 17.1 GW) and hydropower capacity had decreased by 29.8 percent (from 6.7 GW) in the same period (UNDP, 2023; Wilson Centre, 2024). Back in November 2023, the World Bank estimated that Ukraine's energy sector had sustained USD 12 billion in damages during the war (World Bank, 2023). This number is only growing.

Figure 1. A photo of the Northern Birdge over the Dnipro River in Kyiv illuminated by car headlights during a "blackout", as the city is left without electricity supply after critical civil infrastructure was hit by russian missile attacks, amid russian military agresison of Ukraine, November 2022. Author: Valery Hitraya; Source: Wikipedia.org (CC BY-SA 4.0).

The bombing campaign has continued throughout 2024, targeting a wide range of energy infrastructure, from transmission networks to power plants, oil refineries, district heating facilities, and, more recently also, gas storage facilities, which are central to the operation of Ukraine's thermal power plants (OSW, 2024). Despite improvements to Ukraine's air defence systems provided by foreign support, it had been impossible to safeguard the extensive network amid ongoing attacks on the power system (IEA, 2023).

It can be argued that the russians have set out to physically destroy all traditional generation facilities of DTEK, Ukrhydroenergo, and Centrenergo, and so far, they have been successful in their goal (EP, 2024). On March 22nd, 2024, Ukraine saw one of the biggest attacks on its electricity infrastructure since the beginning of the war, during which russia launched 151 rockets and UAVs. Massive attacks continued throughout April.

Thermal power under attack

As a result, most of Ukraine's largest Thermal Power Plants, including, among others, the Kriviy Rih TPP, Prydniprovska TPP, Burshtyn TPP, Ladizhyn TPP, Dobrotvir TPP, Zmiivska TPP, Kalush TPP, Kharkiv CHPP-5, Kharkiv CHPP Eskhar, were either significantly damaged or destroyed. The most powerful power plant in the Kyiv region, situated in Ukrayinka by the Kaniv Reservoir of the Dnipro Cascade — the Trypillia TPP, which was serving the regions of Kyiv, Zhytomyr and Cherkasy, was also completely destroyed on April 11th. As of April 2024, 80% of Ukraine's thermal power plants are said to have been damaged (UNN,2024). Most of the facilities are now either irreparable or will require very long-term repairs lasting 1-3 years. Other power plants have found themselves occupied by russia either since 2014 or since 2022, most importantly in the Donetsk region, where many energy facilities are concentrated. The DTEK company, which accounts for around 70% of the electricity generated in heating and power plants, announced that it had lost almost 50% of its generation capacity in this segment (OSW, 2024).

Figure 2. Photo of destroyed energy facilities at one of Ukraine's Thermal Power plants, due to russian missile attacks. Author: unknown; Source: DTEK

Name	Location	Capacity (MW)	Status
Burshtyn TPP	Ivano-Frankivsk region	2300	Damaged on March 22, 2024
Vuhlehirsk TPP	Donetsk region	3600	Under russian occupation since 2022
Dobrotvirsk TPP	Lviv region	600	Damaged
Zaporizhzhia TPP	Zaporizhzhia region	3600	Under russian occupation since 2022
Zmiiv TPP	Kharkiv region	2175	Destroyed on March 22, 2024
Zuyiv TPP	Donetsk region	1270	Under russian occupation since 2014
Kryviy Rih TPP	Dnipropetrovsk region	2820	–
Kurakhiv TPP	Donetsk region	1460	Damaged
Ladyzhyn TPP	Vinnytsia region	1800	Damaged on March 22, 2024
Luhansk TPP	Luhansk region	1450	Under russian occupation since 2014
Myroniv TPP	Donetsk region	115	Under russian occupation since 2014
Prydniprovska TPP	Dnipropetrovks region	2400	Damaged
Slovyansk TPP	Donetsk region	880	Damaged
Starobeshiv TPP	Donetsk region	2275	Unde russian occupation
Trypillia TPP	Kyiv region	1800	Destroyed on April 11, 2024

Name	Location	Capacity (MW)	Status
Kyiv CHPP-5	Kyiv	700	Damaged on October 10, 2022; again on March 9 2024
Kharkiv CHPP-5	Podvirky, Kharkiv region	540	Damaged on March 22, 2024
Kyiv CHPP-6	Kyiv	500	–
Severodonetsk CHPP	Severodonetsk	260	Destroyed on June 29, 2022
Kremenchuk CHPP	Kremenchuk	255	Destroyed on April 24, 2022
Cherkasy CHPP	Cherkasy	230	–
Chernihiv CHPP	Chernihiv	210	Damaged on February 28, 2022 and later

Note: The tables above present information for all of Ukraine's TPPs as well as the seven largest CHPPs. We have attempted to collect data about the current status, however, providing the limited information, some inaccuracies are possible.

Hydropower under attack

A similar situation can be observed in Ukraine's Hydroelectric power facilities. The deadly and devastating terrorist destruction by russia of the Kakhovka Dam in June 2023 is just one example, albeit the most significant. While the Kakhovka Hydroelectric Power station was an energy source, its destruction, however, goes far beyond the energy dimension, and is therefore discussed in much more detail in the next section 3.3. Kakhovka Dam Destruction.

Aside from the Kakhovka Dam, other major Hydroelectric Power Plants have been targeted since the beginning of the full-scale invasion. For instance, the DniproHES in Zaporizhzhia suffered significant damage as a result of russian missile and drone attacks on March 22nd, requiring significant repairs that could last years. Luckily, the dam itself suffered no damage. Other dams on the Dnipro River, including the Kaniv and Kremenchuk dams, have repeatedly been targeted, as have other major HES on the Dnister River. According to the Ukrainian environmental organisation Ecoaction, by the beginning of 2024, attacks on hydropower plants in the country are over 50 and growing (Ecoaction, 2024).

Figure 3. Photo of the damaged DniproHES, after a russian missile and drone attack on March 22, 2024.
Author: unknown; Source: Denys Shmyhal (Prime Minister of Ukraine) / Telegram

Renewables under attack

Renewable energy sources, which have seen a sharp increase in the last years, have also been 'caught in the fire' since russia's aggression against Ukraine, not only being directly targeted by russian attacks but, perhaps more importantly, Ukraine's most valuable lands for RES remain under russian military occupation in Crimea and the southern regions of the country. As of May 2023, an assessment by the Energy Charter reported that 25% (2.5 GW) of RES facilities remain under occupation, while another 6% of the total installed RES capacity has been either destroyed or damaged. Of Ukraine's largest source of renewable energy — solar (PV) capacities — about 13% are under occupation, and 8% are destroyed, including hundreds of prosumer installations. While the territories with the highest wind potential are concentrated along Ukraine's south coasts of the Black and Azov seas, approximately 80% of wind generation capacities are currently under illegal russian occupation, while at least 10 wind turbines are known to have been damaged by the hostilities (1%). The recorded damage to bioenergy facilities is relatively smaller but nonetheless significant, as at least four plants were shelled and damaged since the beginning of the full-scale invasion (Energy Charter, 2023). In addition to the occupation and destruction of many facilities, the ongoing war has also complicated construction works on several facilities (Razumkov Centre, 2022).

Figure 4. Photo of damaged photovoltaic panels as a result russian missile attacks.
Author: unknown; Source: DTEK

3.2.2. Nuclear risks and threats: Zaporizhzhia NPP under russian occupation

So far, the only energy facilities that have not been directly attacked are the three nuclear power plants of Ukraine's Energoatom, which are still under Ukraine's control. However, such a possibility cannot be excluded, given russia's activity at other nuclear energy facilities to date. Two weeks into russia's full-scale invasion of Ukraine, russian troops occupied the Zaporizhzhia NPP site in southern Ukraine. Located some 60 kilometres south of the city of Zaporizhzhia, the site sits in the port of Enerhodar on the bank of the Dnipro River, whose waters cool its six VVER-1000 nuclear reactors (Le Monde, 2023). In peacetime, the plant produced over a fifth of Ukraine's electricity, making it the largest and most powerful nuclear power station in Europe. Since March 4th, the site has been under the illegal occupation of the russian armed forces and russia's State Nuclear Corporation, Rosatom.

For two years, the Zaporozhzhia plant has suffered multiple hazards and risks due to russian action. On eight occasions, the site has lost all connections to the main electric grid. This means emergency diesel generators are required to operate to maintain safety functions, such as pumps for operating cooling water systems. Diesel generators have limited fuel to operate and are vulnerable to breakdowns. Loss of cooling functions in nuclear reactors with highly radioactive and hot nuclear fuel can lead to rapid water temperature increase, which eventually boils off, exposing the nuclear fuel, which is then no longer cooled. This is what happened at the Fukushima Daiichi nuclear disaster in Japan. Following the russian seizure of Zaporozhzhia, all six reactors at the site have been in shutdown. However, the nuclear fuel in the reactors, and the hundreds of tons of spent reactor fuel, remains hot and needs cooling. The risks remain for a major release of radioactivity from the nuclear fuel if key safety functions are not maintained.

With the russian destruction of the Nova Kakhovka on June 6th 2023, and the resultant drainage of the Kakhovka reservoir, the main water supply source for the Zaporozhzhia nuclear plant was lost. The site has a large cooling pond, as well as a water channel and spray ponds, together with underground wells that were excavated in the summer of 2023. This means that under present conditions of no operation of reactors, sufficient water on the site is reported to maintain vital cooling operations. However, if Rosatom tries to restart one or more reactors, much more water will be needed for cooling, and this cannot be organised in a safe way in the current situation and water supply challenges.

The russian threat to the Zaporozhzhia nuclear plant is severe under present conditions. But it could be even worse. The possibility of the deliberate destruction of the Zaporizhzhia nuclear plant must be considered. After the destruction of the Nova Kakhovka dam and reservoir, all scenarios are possible. There is a very wide range of potential actions and consequences, from damage limited to the site to a localized significant radiation event (within kilometres) to a severe event that leads to major radioactive contamination over hundreds of kilometres. All are possible under the current war conditions as a result of the russian occupation.

Since even before the attack on Zaporozhzhia, Greenpeace, among many others, has warned of the russian threat to Ukraine's nuclear plants, in particular, Zaporiozhzhia, but also the other three operating nuclear plants at the South Ukraine Plant, Rivne and Khmelnytskyi. All are vulnerable, including to missile strikes and loss of electrical power. It is clear that the russian armed forces deliberately targeted Ukraine's nuclear plants, including also an attempt to attack and seize the South Ukraine plant in Mykoliav, which was stopped by Ukrainian defenders. The russian armed forces have used the Zaporizhzhia as a military site and to operate their rocket forces close to the nuclear plant to fire over the Kakhovka reservoir, hitting Ukrainian communities, knowing that Ukraine's armed forces are not able to strike back due to the risks to the nuclear plant. At the beginning of April 2024, the IAEA stated that the Zaporizhzhia NPP was attacked at least three times by "unknown drones" (IAEA, 2024). Later that month, Ukraine's Main Intelligence Directorate (GUR) received evidence that russians were using kamikaze drones over the nuclear reactors. While the situation there has sparked international alarm, other dangers have gotten less attention. One of the Soviet Union's largest processing plants for nuclear fuel sits near the river, outside the city of Dnipro — long neglected, though it holds an estimated 40 million tons of radioactive waste, according to a 2020 report by the Bellona Foundation, a Norwegian environmental group. Scientists have warned of an environmental catastrophe if the facility is shelled and waste contaminates the river (NYTimes, 2023). Overall, the risks of nuclear contamination persist alarmingly in Ukraine and in the world, as russia continues to its dangerous provocations at the Zaporizhzhia NPP.

Figure 5: A photograph of a Russian checkpoint near the Zaporizhzhia nuclear plant in Ukraine
Author: Alexander Ermochenko/Reuters

The Chornobyl distaster (1986)

The fear of a nuclear catastrophe is not without reason, particularly in Ukraine. On April 26th, 2024, Ukraine marked 37 years since the Chornobyl Catastrophe. The destruction of reactor unit 4 of the Chornobyl nuclear power plant in April 1986 is described as one the largest man-made disasters in the history of mankind. The destruction released enormous amounts of radioactivity into the environment of Ukraine and across Europe. The consequences for hundreds of thousands of workers (liquidators) and the general population who were contaminated have been devastating in terms of premature death and major health impacts.

The environment of Ukraine, including the Dnipro River and thousands of square kilometres around the plant, was heavily contaminated by radioactivity, which is still a major ecological issue today. Damage to people and nature is still being studied, and the entire territory within a radius of 30 km of the exploded reactor, with a total area of more than 2600 km2 (larger than the country of Luxembourg), remains uninhabited and closed to economic activities even today. Thousands of Ukrainian staff continue to oversee the enormous task of monitoring the conditions of the destroyed reactor unit 4 and the other permanently shutdown reactors.

Figure 6. Aerial view of the Chornobyl Nuclear Power Plant, 2007
Author: IAEA Image Bank; Source: Wikipedia (CC BY-SA 2.0)

Chornobyl NPP under russian occupation (2022)

On the first day of the full-scale invasion, on February 24th 2022, the Chornobyl plant was attacked and seized by russian armed forces. During five weeks of occupation, the important laboratory operated by Ukrainian scientists who are responsible for monitoring and investigating the highly radioactive contaminated exclusion zone was vandalised by russian troops. Workers at the site were subjected to threats and intimidation. Vital equipment was destroyed or stolen by the invaders. The work at the nuclear power plant was severely disrupted by the russian occupiers (Greenpeace, 2022).

The conditions at Chornobyl have not returned to what they were before February 2022 - the plant is on the frontline with the reactors only 16km from the border of Belarus. Much of the important scientific work at the plant and in the surrounding exclusion zone has had to stop due to the russian war. This includes increasing our understanding of how radioactive contamination moves through the environment, including in groundwater and into the water systems - lakes, the River Pripyat, and eventually downstream into the Dnipro River.

Figure 7. CCTV Footage of russian military convoy equipment heading through the Chornobyl Exclusion Zone on February 24th, 2022 – the first day of the full-scale military invasion. Source: State Agency of Ukraine on Exclusion Zone Management (SAUEZM)

3.2.3. How resilient is Ukraine's energy system?

Before the invasion, russia and belarus together provided more than half of the fuel consumed by Ukraine. The country faced a fuel crisis as these supplies stopped and domestic refining capacities were destroyed. Since the russian invasion, major sources of energy, including thermal and nuclear power plants, remain under occupation. Moreover, 30% of Ukraine's solar capacities and 90% of its wind power capacities remain in the occupied territories. Despite the war-related devastation of both the infrastructure and the economic profile of the energy sector, Ukraine has laid down a good track record in reforms, as evaluated by European observers (Wilson Centre, 2024). During the ten years of war since 2014, but especially since the beginning of the full-fledged invasion, Ukraine has resolutely adopted norms and legislation to achieve deeper integration with the European Energy Community while achieving energy independence from russia.

On March 16th, 2022, 3 weeks into the full-scale invasion, the electricity grids of Ukraine and Moldova were successfully synchronised with the Continental European Grid — the European Network of Transmission System Operators for Electricity (ENTSO-E). This has, among others, been a significant factor that allowed Ukraine to better absorb shocks to the system and keep its energy system alive in the face of constant russian attacks. In addition to that, aided by significant grants, loans and investments from a wide range of governments, multilateral donors and the private sector – Ukraine undertook the biggest energy infrastructure repair and maintenance campaign in the country's history (Ukraine Government Portal, 2023). The Ukrainian government also strengthened its air defence systems and invested in passive defence measures such as engineering fortifications to further protect energy infrastructure. However, initiatives to protect its infrastructure against shelling have proved insufficient in mass-scale attacks (IEA, 2024). Restoring facilities that have already been severely damaged or destroyed is a challenging and long task, requiring securing financing to repair coal-based generation and sourcing high-power autotransformers, a critical component of Ukraine's Soviet-legacy power system (OSW, 2024).

What the current war has also revealed is that the highly centralised, fossil-fuel and nuclear energy-dependent system has a number of limitations for the security, economy and well-being of the country and its citizens. Before the full-scale invasion, the largest sources of energy in final consumption in Ukraine were natural gas at 27%, electricity at 21%, and oil products at 21%. The energy system was and still is heavily dependent on fossil fuels and nuclear power, and it's no surprise that Ukraine is in the high 31st position in the global ranking of CO2 emissions per country (IEA, 2021). In terms of electricity generation, Ukraine relies mostly on nuclear power. The second is coal. The share of renewable sources in the energy mix is also growing.

On the other hand, despite the tragic consequences of the Chornobyl disaster and the risks that emerged with the russian full-scale invasion and occupation of several nuclear facilities, the nuclear industry continues to play a defining role in Ukraine's energy system. After Ukraine gained independence in 1991, a moratorium was imposed on the construction of new reactors, but it was lifted just two years later and old nuclear projects were restarted. Zaporizhzhia-6 became operational in 1996, Khmelnytskyi-2 and Rivne-4 in 2004. Construction of all 3 reactors had begun in 1986. More recently, amid the full-scale war, Ukraine's Energy Minister, German Galushchenko, announced that the construction of four new nuclear reactors will begin in the summer or autumn of 2024 on the site of the existing Khmelnytsky NPP in western Ukraine, as the country seeks to compensate for lost energy capacities, especially the occupation of the Zaporizhzhia NPP (Reuters, 2024).

Figure 8. A photo of a crew reparing electricity grids in Ukraine after a russian missile attack has damaged the infrastructure. Author: unknown; Source:DTEK

In addition to that, the current energy system of Ukraine is characterised by a significant share of base-load capacities, which are not designed for frequent and rapid changes in operating modes. Instead, capacities capable of performing this function to balance the system have exhausted their park resources or have been lost due to russian airstrikes and occupation.

The loss of a notable portion of "the balancing capacity, which enables the operators to regulate the amount of electricity fed to the grid to keep the daily supply and demand in balance", poses another major problem for Ukraine (OSW, 2024). The task of system balancing is carried out by thermal power plants and hydroelectric stations, most of which have been under severe attack by russia, resulting in significant damages or complete destruction of major power facilities.

While electricity imports from the EU (which have now reached record levels, see Chart 1) can help to stabilise the situation, they are unlikely to compensate for all lost capacity, urging the government to return to scheduled power shutdowns for individual customers similar to those applied in winter 2022/23 (OSW, 2024).

3.2.4. Energy efficiency

Another major problem that existed before the war but which gained increased importance since the full-scale invasion is the issue of energy inefficiency. As mentioned above, even prior to the full-scale invasion in 2022, Ukraine's energy system still bore many of the characteristics of the old Soviet economy, such as heavy dependence on fossil fuels and nuclear power, energy-demanding industry processing raw materials, and low energy efficiency both in the industry sector, housing and utilities, and transportation. The energy intensity was driven by high demand in residential heating, an industrial structure that is concentrated in capital and energy-intensive activities, and an energy-inefficient industrial, energy, and building infrastructure due to decades of under-investment (UNECE, 2023)

The indicator that best describes that is the energy intensity of the economy – that is, how much energy a country uses to produce a unit of its GDP. Over the past 20 years, Ukraine has made significant progress, performing 56% better in 2022 than in 2000, but the country's economy is still very energy-intensive. According to the head of the State Agency for Energy Efficiency and Energy Saving of Ukraine, Anna Zamaziyeva, the amount of energy used to produce one unit of goods and services in Ukraine (i.e. energy intensity of GDP) is 2.5 times higher than the same indicator in Poland and three times higher than in Germany (EP, 2024). In 2020, it remained in 18th place among 147 countries behind Syria, Congo, Iran, Kuwait, and the second most energy-intense on the European continent after russia (Enerdata, 2023; IEA, 2020). The high energy intensity of the economy is an obvious challenge to the development and competitiveness of the country in the future.

Even though some serious progress has been made, especially in the residential and agricultural sectors, the potential to further reduce emissions by using energy more efficiently is high, as various historical factors continue to impact Ukraine's energy landscape to this day. Heat is delivered through poorly maintained distribution systems to individual users who are sometimes not even metered and have no means of controlling their use. Thermostatic radiator valves or heat meters are a rare occasion, and most Ukrainian homes, public buildings and social infrastructure facilities such as hospitals, kindergartens and schools have poor thermal insulation or old windows. Due to low energy efficiency in the economy, Ukraine's annual losses exceeded one billion US dollars (EP, 2024).

Since February 2022 (and to a lesser extent since 2014), the issue of energy efficiency acquired new, not only economic significance. Since the beginning of the full-scale invasion, as Ukraine's energy sector took a hard hit, losing significant capacities and as supplies of electricity became more scarce, the question of energy intensity also became a matter of energy resilience and a matter of security. The question now shifts from merely a question of economic losses and low-carbon, climate-friendly solutions to one of strategic importance, as a reliable energy supply affects the sovereignty and independence of the state (SAEE, 2023).

3.3. Kakhovka dam destruction

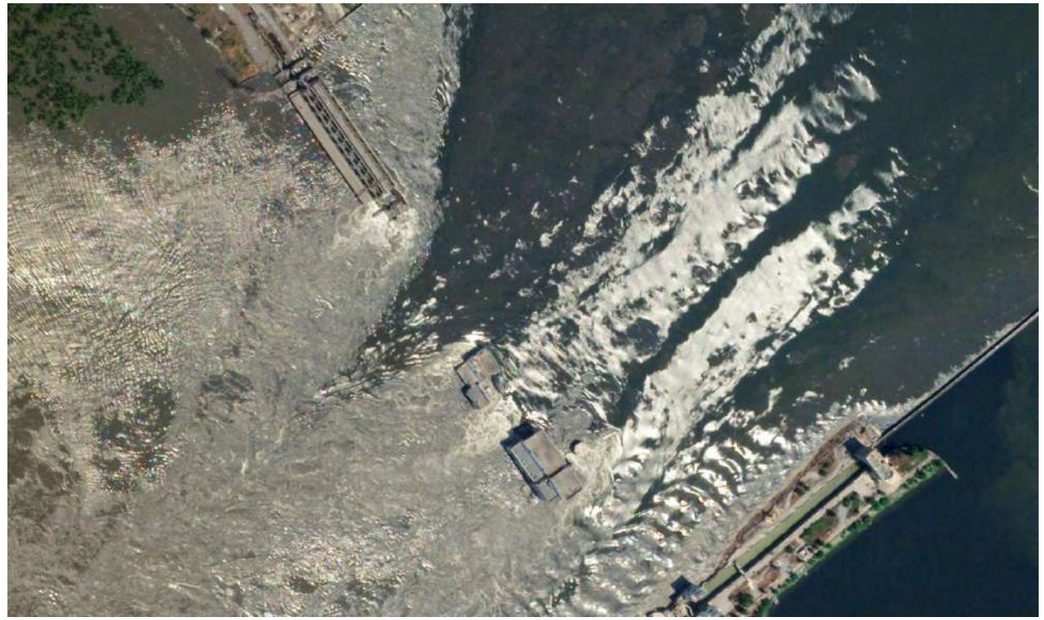
3.3.1. Kakhovka dam: overview

As described in the previous chapters, the Kakhovka hydroelectric power plant located near the town of Nova Kakhovka in southern Ukraine was completed in 1956 and was the last of the six hydroelectric power stations of the Dnipro Cascade. The dam itself was massive, spanning 3.2 km in length and 37 m in height. With a volume of 18 km3 and a surface area of 2,092 km2, its upstream reservoir was the largest by volume and the second largest by surface not only in Ukraine but also in Europe (excluding Turkey and russia). At the time of its destruction, the dam's installed hydroelectric capacity was 357 MW, amounting to approximately 5% of Ukraine's total hydropower. Beyond the generation of energy for southeastern Ukraine, the Kakhovka dam played an important role in providing water for municipal use, irrigation water for agriculture in southern Ukraine and Crimea, ensuring the safety of the Zaporizhzhia nuclear power plant by supplying its cooling ponds, fishing, recreation and others (CEOBS, 2023).

Figures 1 and 2. A pair of satellite images shows the Kakhovka dam before and after its destruction in early June 2023. Source: Planet Labs (CC BY-NC 2.0)

3.3.2. Kakhovka dam destruction: war crime and ecocide

In the early hours of June 6th 2023, at about the same time when local residents reported hearing large blasts, seismic monitoring in Ukraine and Romania detected the telltale signs of large explosions at precisely 2:35 a.m. and 2:54 a.m. (NYTimes, 2023; CEOBS, 2023). Despite the fact that the dam had sustained some damage throughout the conflict, the evidence clearly suggests that the collapse was no accident and that the dam was crippled by a targeted explosion set off by the side that controls it: russia" (NYTimes, 2023). Russia had occupied the facility since the first days of its full-scale invasion in February 2022 and, as an occupying power, was obliged to ensure its safety (CEOBS, 2023). Far from it. Drone footage from the scene reveals that the section initially breached in the incident was around 85 m long. Numerous technical assessments suggest that to cause such sufficient damage, explosives would have had to be set deep within the dam's structure. Even in a war that has razed entire cities, the destruction of the Kakhovka hydroelectric dam in southern Ukraine and the subsequent flood, forcing the evacuation of tens of thousands of civilians and causing widespread damage, stands out (NYTimes, 2023). Ukraine president Zelensky has called the attack "an environmental bomb of mass destruction" and the ensuing flood event an act of "brutal ecocide" (Hakiman, 2023).



The ecocide caused by the dam disaster has too many dimensions to fully summarize its impacts. Generally, the consequences of russia's terrorist attack can be divided into two categories: first, the consequences of the flooding downstream of the Dnipro River and second — the consequences of the desiccation of the Kakhovka Reservoir upstream of the dam.

To note the most notable impacts of this war crime, we will focus on the humanitarian, economic and ecological damages, which include (Vox Ukraine, 2023):

- The immediate humanitarian crisis, with thousands of people displaced and 52 people losing life due to the flooding;
- The loss of amenity services, which include water supply and drainage services in cities and other populated areas, as well as the generation of electricity;
- The loss of irrigation water for agriculture farms and the drying up of the landscape;
- The massive loss of habitats with long-term implications for the degradation of ecosystems and reduction in biodiversity due to both flooding itself and the environmental pollution from household and industrial water contamination caused by flooding;
- The physical damage to infrastructure, including residential, industrial and agricultural facilities, and others (Vox Ukraine, 2023).

To add to that, monitoring and measuring the damage inflicted on the environment in conflict zones is an extremely challenging and hazardous task, compounded by a lack of manpower and equipment. However, in part thanks to advanced satellite monitoring systems, we are able to observe some key parameters. (Vox Ukraine, 2023)

After the initial breach of the dam's first section, the force of the rushing water gradually widened the gap in the dam, leading to the uncontrolled release of water from the reservoir and a disastrous rise in water levels downstream. For those nearest to the dam, the surge of water occurred almost instantly. It took more time for the floods to reach areas farther downstream, but once they did, they surged rapidly and then remained at high levels for over a week. (NYTimes, 2023). In the immediate aftermath of the explosion, this substantial water store inundated thousands of houses and farmlands along the Dnipro River before flowing into the Black Sea (LSEG, 2023).

Estimates from UNOSAT suggest that approximately 620 km2 of land along both banks of the Dnipro River were flooded between the 6th and 9th of June, affecting up to a hundred thousand people (UNOSAT, 2023; CEOBS, 2023). Water levels reached a peak of 5.6 metres on June 8th before receding gradually, according to Ukrainian authorities. By June 13th, a week after the dam's destruction, the flooded area had decreased to 180 km2, and between July 5th and 20th, the floodwaters receded by a further 100 km2 (UNOSAT, 2023; CEOBS, 2023), gradually revealing the damages it had inflicted. The flood affected both residential, industrial and agricultural areas, as well as ecologically important habitats.

Figure 3. Pair of satellite images shows the city of Kherson and its surroundings before (June 1, 2023) and after (June 9, 2023)the destruction of the Kakhovka dam, which resulted severe flooding along the Dnipro River, several thousand homes inundated, tens of thousands of people loosing power, and more than 40,000 forced to evacuate. Source: NASA / Landsat Image Gallery

Figure 4. Photo of n elderly woman observes the flood from her balcony in Kherson, June 2023.
Author/Source: Alyona Budagovska.

3.3.3. Humanitarian crisis and the loss of critical amenities

Downstream

As a consequence of the flood, the death toll reached 52 people, with 35 deaths reported by russian officials on occupied territories and another 17 deaths reported by Ukraine. Due to the damage to residential and critical infrastructure caused by the flood, including water, food, and health facilities, more than 11,000 people were evacuated on both sides. The soaring humanitarian crisis was aggravated by russian shelling of civilian evacuation convoys organised from the Ukraine-controlled right bank (Vox Ukraine, 2023).

Downstream flooding affected more than 86.54 km2 of urban areas on both banks of the river, with the russian-occupied left bank being more affected due to topographic differences (CEOBS, 2023). For instance, according to satellite imagery, over 60% of the town of Oleshky, situated on the left bank of the river, was flooded as of June 7th. Sitting on the right bank, the city of Kherson saw around 20% of its surface flooded, with an estimated 4,300 structures across 12 km² affected. The Government of Ukraine informed that a total of 80 towns and villages were partly or completely flooded, with 31 in the Mykolaiv oblast and another 49 in the Kherson oblast, both in the Ukraine-controlled right bank and the left bank under russian military control. Preliminary estimates by the Kyiv School of Economics indicate that approximately 20 to 30 thousand houses were affected by the flooding, including at least 150 multi-story buildings in the city of Kherson (KSE, 2023). The destruction of housing and infrastructure in the south, however, was not the main outcome of the terrorist act.

Upstream

In addition to the flooding, the rapid decrease in the levels of the Kakhovka reservoir upstream of the dam had an impact on the provision of key ecosystem services, including water supply, wastewater treatment, recreation, energy provision and aquaculture (CEOBS, 2023). Firstly, the destruction of the dam itself logically deprives the people in the region of an important source of renewable energy. The KSE noted that of the total amount of direct losses caused by the explosion of the Kakhovka dam estimated at over $2 billion, more than a quarter is related to the Hydropower Station valued at $586 million (KSE, 2023).

Apart from its role in regulated energy generation through the Kakhovka hydroelectic power station, the waters of the Kakhovka reservoir were also an essential source of water for the population of southern Ukraine. According to the Ministry of Environmental Protection and Natural Resources of Ukraine, the Kakhovka reservoir provided a centralised drinking water supply for around 700,000 people, and its destruction has led to severe shortages across several areas, including towns like Apostolove (18,000 people), Pokrov (48,000 people), Nikopol (60,000) and the entire Marhanetska hromada (70,000 people) (UNOCHA, 2023). The Ukrainian Water Agency reported that the total water volume lost is equivalent to the total water needs of Ukraine for 1.5 years (UNECE, 2023).

Figure 5. Photo of a man on a boat on the flooded streets of Kherson after the destruction of the Kakhovka dam, June 2023. Author/Source: Alyona Budagovska.

Figure 6. Photo of residents of flooded areas of Kherson and their domestic animals evacuated on rubber boats, June 2023. Author/Source: Alyona Budagovska.

3.3.4. Impact on agriculture

Downstream: flooded farmland

The destruction of the Kakhovka dam also had a very significant impact on Ukrainian agriculture — one of the main sectors of the country's economy. On the one hand, downstream flooding directly affected farmland, with approximately 10,000 hectares of agricultural land submerged underwater on the right bank of the Kherson region, according to the Ministry of Agrarian Policy and Food of Ukraine. Direct flooding losses are estimated at about 10,000 tons of corn, 100,000 tons of wheat and 26,000 tons of rapeseed in the Kherson oblast. However, with many more thousands of hectares on the left bank being under russian military occupation, the full extent of the damage is hard to quantify (LSEG, 2023). The long-term consequences are yet unknown, but the flooded areas will likely not be cultivated in the coming years.

Upstream: loss of water for irrigation

While the impact of the flood had notable ecological and economic damages for the agricultural sector, a much more significant and worrying impact on agriculture came from the loss of water in the Kakhovka reservoir upstream of the dam. One of the most critical functions of the reservoir was indeed that, along with providing drinking water, it served as the primary source of irrigation water for much of the Kherson region and Crimea (Vox Ukraine, 2023). Water from the reservoir was distributed through several main canals, including the North Crimea Canal, The Main Kakhovka Canal and the Dnipro-Kryvyi Rih Canal 2.3. Agriculture and fishing and then further distributed through 12,000 km of irrigation canals and ditches, irrigating nearly 600,000 hectares, 90% of which are currently under russian occupation (Vox Ukraine, 2023).

According to the Ministry of Agriculture of Ukraine, the disruption of 31 irrigation systems due to the destruction of the Kakhovka dam will leave 584,000 hectares of land in Ukraine's naturally arid south regions of Dnipropetrovsk, Kherson, and Zaporizhzhia oblasts without irrigation, putting them at risk of turning into deserts (CEOBS, 2023). More precisely, as much as 94% of irrigation systems in Kherson, 74% in Zaporizhia and 30% in Dnipropetrovsk will now not be able to operate normally, inevitably leading to a reduced yield potential in these regions for the foreseeable future (LSEG, 2023). As noted by Ukraine's Ministry of Agrarian Policy and Food, there is a high risk that the loss of irrigation in more unviable areas will lead to abandoned land reverting back to steppe, while in other areas, increased dependencies on groundwater abstraction will further exacerbate aquifers and lead to the salinisation and erosion of soils (Kyiv Independent, 2023).

The destruction of the Kakhovka dam, which resulted in the waters of one of Europe's largest reservoirs being lost to the sea, not only puts the Ukrainian agricultural and economic potential at stake in the short to medium run but rippling through supply chains, imperilling critical infrastructure and threatening fragile ecosystems for decades, it puts millions at risk while affecting food security around the world.

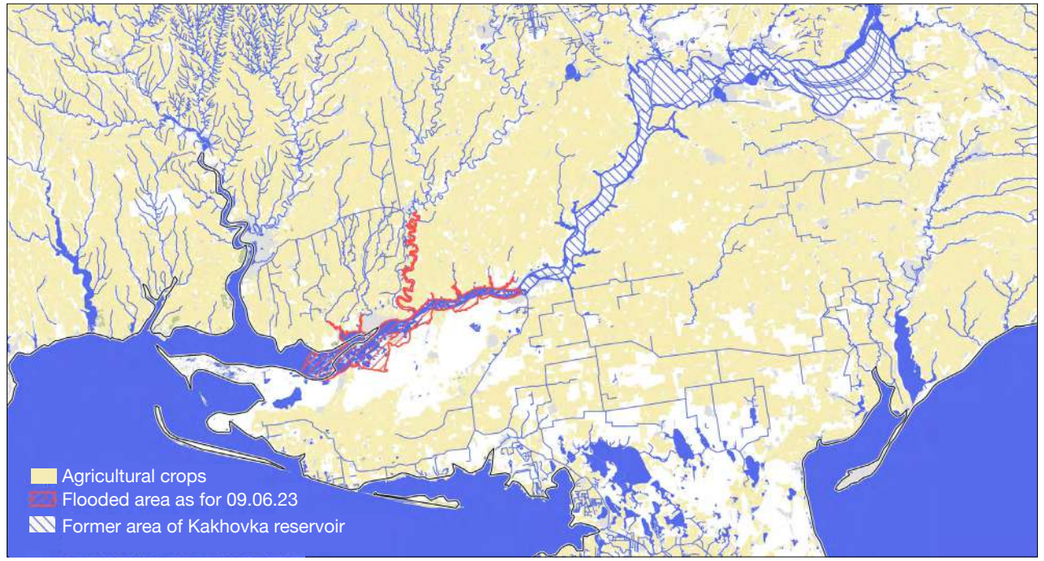


Figure 6. Map of agricultural land, water chanels (including irrigation canals), and the areas impacted by the destruction of the Kakhovka dam. Elaborated by Ro3kvit and Greenpeace CEE

Figure 7. Pair of satellite images shows the impact of the Kakhovka dam breach on agriculture (left: May 17, 2023; right: June 18,2023), as networks of canals once fed by the Kakhovka Reservoir have become disconnected from the source of water and are drying out, leading to the browning of fields. Source: NASA Observatory / Landsat Image Gallery.

3.3.5. Impact on industry, transportation, and the economy

Downstream

The destruction of the dam also impacted the industry sector. Apart from the Hydroelectric power station lost to the explosion itself, the flooding inflicted significant damages to various energy infrastructure facilities, including electrical grids. While bearing significant financial costs in the order of hundreds of millions of dollars, the damage to other facilities also led to significant environmental harm. An analysis by CEOBS revealed a total of 88 hazardous sites visibly impacted by floodwater, 49 of which were situated in areas of Ukrainian control and the other 38 on the russian-occupied left bank. The flooding of these and other industrial facilities resulted in the discharge of substantial amounts of fuels and other pollutants. According to a report by KSE, 17 petrol/gas stations and two oil depots were submerged under water, contributing to releasing as much as 150 tons of oil into the environment (KSE, 2023).

While industry accounts for a major release of toxic substances into the water, households can also be a significant source of pollution. Various oils, household chemicals, solid waste, and, importantly, asbestos fibres found in at least 60% of all roofing materials in Ukraine pose significant concerns for the environment (CEOBS, 2023). In addition to pollution from larger industrial facilities and residential buildings, floodwaters also affected sewage pits and landfills in settlements on both banks, as well as agricultural facilities which contained fertilisers and pesticides harmful to the aquatic and land biota (CEOBS, 2023; Vox Ukraine, 2023).

Transportation and mobility also suffered significantly both on land and on water. Over 290 km of roads were flooded, and several railways left in need of maintenance. In terms of river navigation, floods have affected several river ports facilities in Kherson, but most importantly, the flood has accentuated another significant caveat of war-time navigation: mines.

Made relevant by the ongoing war along the Dnipro River is military waste, in particular — mines. According to an analysis conducted by CEOBS following the Kakhovka destruction, of a total of 117 russian military objects (including kilometres of trenches, fortified positions, and defensive sites) recorded along the left bank of the Dnipro River occupied by russia, 47 were flooded (38 in areas of ecological significance). These military sites contained military materiel and military wastes, including landmines and unexploded ordnance, some of which were mobilised by the flood, caused to detonate or, in other instances, dislodged by the torrent of water (CEOBS, 2023). The mine threat and adverse sanitary conditions significantly complicate the restoration of the navigation of boats and tourism along the Black Sea coast of Ukraine.

The river anti-landing mines were dislodged from their anchors, and cases of them being washed ashore have already been recorded. However, the greatest danger lies in those mines that have been left drifting in the waters of the Dnipro estuary and near the Black Sea coast of Ukraine. Without additional expenditure on checking and demining the waterways, restoring navigation, even on the Southern Bug, will be problematic.

Upstream

Several significant limitations have also appeared in the upstream Kakhovka Reservoir. The explosion of the Kakhovka dam made it impossible to transport goods along the Dnipro River below Zaporizhzhia (DniproHES) due to the nature of the riverbed. This completely closes off the possibility of grain transportation by river transport (via the Dnipro), thus affecting the development of cargo trans-shipment services. Limited navigation capacity also impacted other industries along the banks of what used to be the Kakhovka Reservoir. For instance, the Nikopol Ferroalloy Plant is reducing production volumes, and “ArcelorMittal Kryvyi Rih” has halted steel production and rolled product manufacturing (UIFuture, 2023). Last but not least, as discussed in the chapters above 3.2. Energy Insecurity, the destruction of the Kakhovka Reservoir “cuts off” the water supply source for cooling the reactors of the Zaporizhzhia Nuclear Power Plant, contributing to energy insecurity in the region with implication far beyond Ukraine’s borders (UNECE, 2023).

Figure 7. Photo of the city of Kherson flooded by the waters of the Dnipro River, after the destruction of the Kakhovka dam. Port cranes and grain elevators seen on the background have also been impacted. Author/Source: Alyona Budagovska.

3.3.6. Impact on the natural environment

Arguably the most significant implication of the destruction of the Kakhovka dam — taking into account the severity of all the consequences listed above — is the environmental harm that was resulted for the ecosystems both upstream and downstream of the dam, from the Kakhovka reservoir down to the Dnipro Estuary and extending far into the Black Sea.

Downstream

Protected areas: Across the affected territories, the Ukrainian National Conservation group identified 47 national protected areas, 16 reservations, three reserve stows, 22 natural monuments, and two monument parks of garden art with a total area exceeding 120,000 hectares (UNCG, 2023). Among them, there are 9 Emerald Network sites that were fully or partially flooded, including the Lower Dnipro (52386 ha), the Oleshkivski Pisky (46259 ha), the Lower Inhulets River valley (13570,98 ha), the Kinburn Spit Regional Landscape Park (46588 ha), the Black Sea Biosphere Reserve (115873 ha), the National Nature Park Ivory Coast of Sviatoslav (35242 ha), the Dnipro-Buh Lyman (71276 ha), the Loess outcrops of the Dnipro estuary (589,20 ha) and the Olviiska khora (1319,56 ha).

The loss of natural features in these territories jeopardises Ukraine's commitments to preserve these areas for the whole of Europe (UNCG, 2023). The most heavily affected area, with over 90% of its surface inundated, was the Lower Dnipro Delta, covering an area of 33,630 ha, which is also designated as a wetland of international importance under the RAMSAR Convention (CEOBS, 2023). As a result of the catastrophic flood, not only the Dnipro River was affected but its tributaries as well, including Ingulets and Viriovchyna.

Flora: While it may seem that water cannot harm plants, a mere rise in groundwater levels can, in fact, be detrimental. The nature and scope of flooding in the area were so severe that hundreds of thousands of individual plants have perished. That is to say, the region was a habitat for a specific flora, including many endemic species with very localised distribution in this region.

Fauna: Quantifying the extent of fauna destruction is very challenging due to the unprecedented nature of the event and the lack of research. However, it is clear that the rapid rise in water levels in low-lying areas and, especially on islands, leaves very little chance for survival for most terrestrial animals (mammals, reptiles, insects, etc.) and colonies of most bird species (UNCG, 2023).

Among the most vulnerable groups of animals to flooding and destruction of biotopes are reptiles and amphibians, including the Steppe viper (Vipera renardi), Caspian whipsnake (Dolichophis caspius), Sarmatian rat snake (Elaphe sauromates), Smooth snake (Coronella austriaca), Sand lizard (Lacerta agilis) and Steppe runner (Eremias arguta) featured in the Red Book of Ukraine and the Bern Convention. Moreover, the areas of the Lower Dnipro flooded by the water from the Kakhovka reservoir are habitats for the largest colonies of herons and other colonial birds in the region, as well as nesting sites of water and shorebird species (UNCG, 2023). The true impact of the flood is yet to be seen.

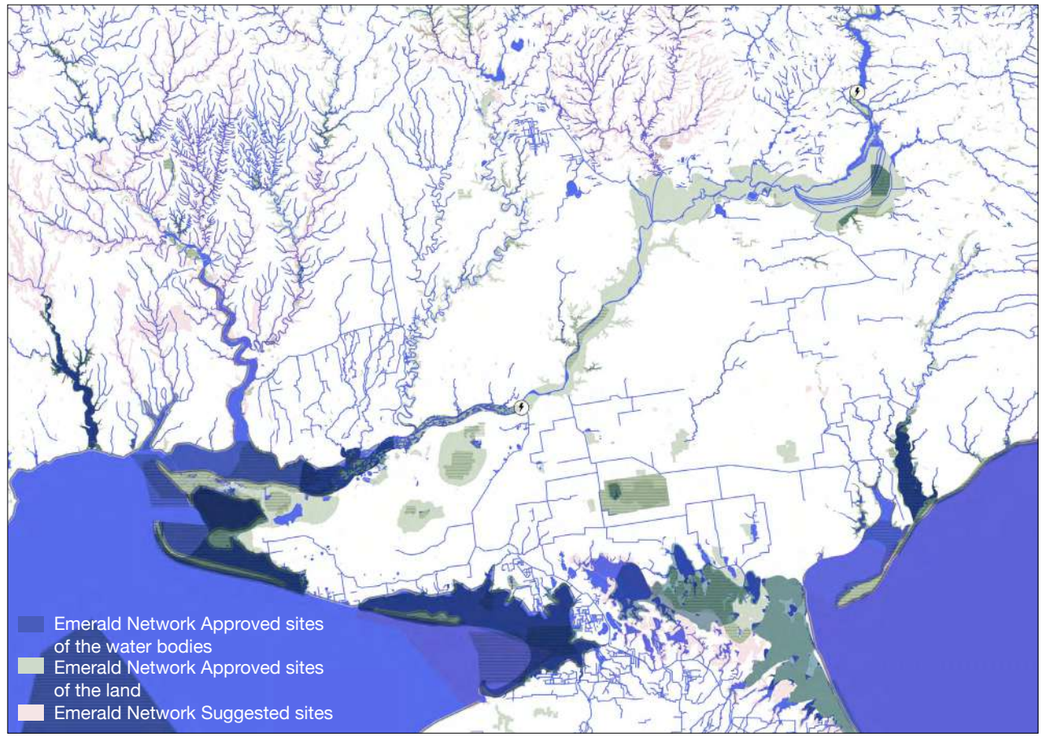


Figure 8. A map of protected natural areas (marked in green) impacted by the Kakhovka dam destruction, both upstream and downstream of the dam. Source: Elaborated by Ro3kvit and Greepeace CEE

The Black Sea

Flowing into the Black Sea, the waters from the Dnipro River have a direct impact on maritime ecosystems. While it is yet challenging to asses the full scope of the damage, the sudden destruction of the Kakhovka dam, followed by the powerful mass of water, leaves us to believe that the discharge of sediments and debris likely had an impact on various seafloor habitats along the northwestern coastline of the Black Sea, including the important and vulnerable Zernov's Phyllophora Fields. (CEOBS, 2023).

Another implication of the sudden input of freshwater into the Black Sea was the reduction of salinity in its northern parts, with samples of water collected near Odesa on June 10th being three times less saline than normal. While temporary, the impact of such a volume of freshwater on salinity may have impacted currents, water mixing, and productivity, as well as led to a 150-300 times increase of plankton blooms, 40-50% of which could be dangerous due to the production of toxins (CEOBS, 2023; UNECE, 2023)

Figure 9. Satellite image of the Kakhovka Reservoir on June 5, 2023, before the destruction of the dam
Source: Copernicus Sentinel-2; Accessed via: RadioFreeEurope/RadioLiberty

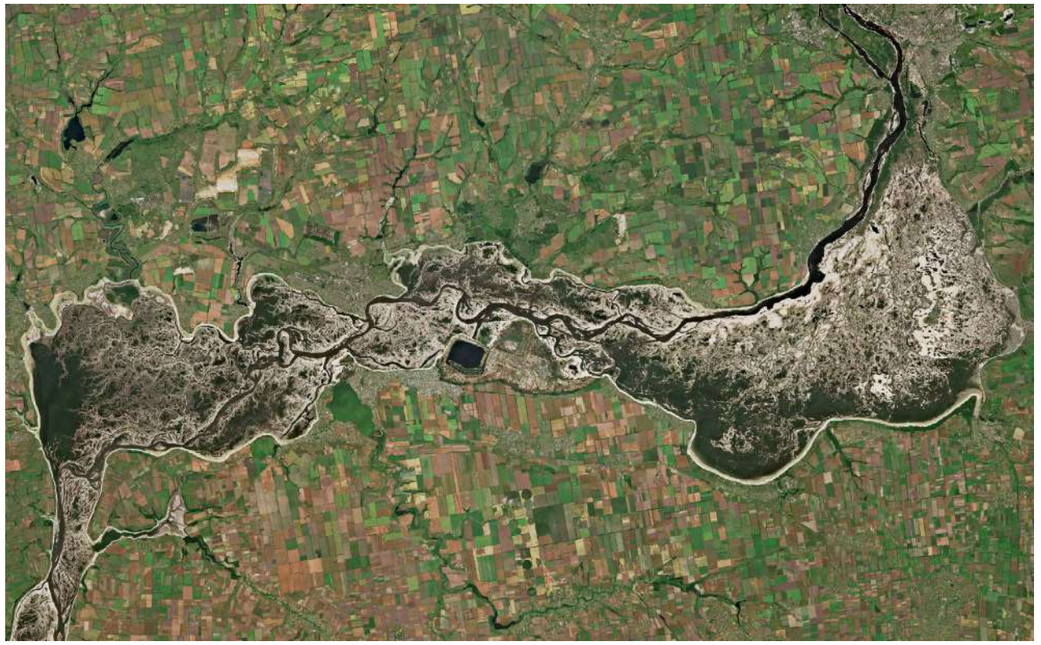


Figure 10. Satellite image of the Kakhovka Reservoir on June 20, 2023, after the destruction of the Kakhovka dam
Source: Copernicus Sentinel-2; Accessed via: RadioFreeEurope/RadioLiberty

Upstream

Protected areas: The loss of water from the Kakhovka Reservoir has led to no less significant impacts on the existing ecosystems. At least 11 nature reserves covering an area of over 250,000 hectares can be identified here, including several protected Emerald Network sites: the Kakhovka Reservoir itself (218,119 ha), the Velykyi Luh (Great Meadow) National Nature Park (16,755 ha), the Bazavluk (65220,25 ha), the National Nature Parks Kamianska Sich (12,261.14 ha) and the Regional Landscape Park Panai, as well as the wetlands of international importance such as the Archipelago Velyki and Mali Kuchugury (7,740.0 ha) and the Sim Maiakiv Floodplain (2,140 ha) (UNCG, 2023; Vox Ukraine, 2023).

Flora: As a result of the catastrophic decrease in water level in the reservoir, aquatic and riparian plants of the Kakhovka Reservoir have disappeared. While some commentators were quick to positively pick up the quick growth of plants on what used to be the Kakhovka reservoir, experts have alerted that the exposed zone of the reservoir bed became the largest hotspot of alien and dangerous invasive species in the region, including the Canadian fleabane (Erigeron canadensis), common ragweed (Ambrosia artemisiifolia), giant goldenrod (Solidago gigantea) (UNCG, 2023).

Fauna: Within the territory affected by the ecological catastrophe, 38 rare habitat types, protected under the Bern Convention, have been identified. Perhaps one of the major impacts of this disaster on fauna is on fish resources. At the time of the terrorist attack, the Kakhovka Reservoir alone was habitat to no less than 43 fish species, of which 20 species have commercial importance (annual catches amounted to up to 2.6 thousand tons). It will take a minimum of 7-10 years to restore such stocks. All spawning grounds and the main volume of water, which are the fish habitats, have been destroyed. As with the downstream, a number of bird species that nest in these places are expected to disappear, including martins and terns (UNCG, 2023).

3.3.7. Conclusions

The scale and scope of the harm inflicted by the destruction of the Kakhovka dam by the russian army are so enormous that likely no single overview can achieve the task of successfully elucidating the many dimensions of the consequences. In the paragraphs above, we have raised just some of the major impacts that have resulted from both the loss of water from the Kakhovka reservoir upstream of the dam and the massive flooding that this flow of water had led to on the territories downstream of the Kakhovka HPP. The consequences encompass the loss of 52 human lives, the displacement of thousands of people leading to a humanitarian crisis, the destruction of major infrastructural facilities, including the Kakhovka HPP itself, the disrupted provision of water both for drinking purposes and for agriculture, the significant pollution caused by the leaking of various oils, toxins and pesticides, the loss of biodiversity as a result of whole ecosystems being damaged, and many others. It is likely that other environmental dimensions will become apparent, undermining climate resilience and food security. The long-term ecological disaster will unfold over decades to come. The explosion of the dam exhibits the characteristics of a scorched-earth strategy, aiming to obliterate anything of potential use to the enemy. The collapse of the Nova Kakhovka dam is likely to be one of the most impactful events in the environmental dimension of the war. The extent of damage to wildlife, natural ecosystems, and entire national parks caused by this event far surpasses the consequences for the environment of all military operations since the beginning of the full-scale invasion in February 2022 (CEOBS, 2023; UNCG, 2023).

3.3.8. Further risks and threats

On March 22nd, 2024, russia launched a huge barrage of missiles and drones at Ukraine's energy infrastructure overnight. Among the targets was the DniproHES — Ukraine's biggest Hydroelectric power plant. Ukrhydroenergo reported two direct hits at HES-1 and HES-2. Russia's defence ministry admitted firing a barrage, including with hypersonic Kinzhal missiles. It is noted that parts of the ceiling and walls in the turbine hall collapsed. Due to the damage, 20% of the regulating capacity was lost. It will be necessary to restore the electrical equipment and hydro units at the station. This time, the situation is "under control" and "there is no threat of breach" (EP, 2024c). However, Ukrainian officials are skeptical, and they have reasons to be: "Russians are trying to create a new ecological disaster" (Ukrhydroenergo, 2024; Politico, 2024).

A week later, on March 29th, in his video address, the President of Ukraine, Volodymyr Zelenskyy, announced that russian missiles and drones had again targeted two dams, the Kaniv Hydroelectric Power Plant and the Dnister Hydroelectric Power Plant. He continued, "This clearly indicates that russia seeks to replicate the catastrophe they caused at the Kakhovska station. It must become a shared task – not only for Ukrainians – to prevent such environmental disasters in Europe. Besides Ukraine, Moldova is also under direct threat" (President of Ukraine, 2024; WP, 2024). On the way up the Dnipro River, five hydroelectric dams are located one after the other. Destroying just one of these structures could severely threaten to replicate the scenario of the Kakhovka dam breach.

The events of the past and of the present show that such possibilities simply cannot be ignored. The Ukrainian state is taking such risks seriously. The State Emergency Service of Ukraine has previously conducted calculations and wargaming of the possible consequences caused by such man-made disasters on rivers. Several scenarios were considered, with some alarming results.

According to the preliminary evaluations, in the event of a breach of the Kyiv HES (the first of six), the resulting floodwaters are estimated to overwhelm and destroy the Kaniv HES, located 43 kilometres downstream. This breach would subsequently raise the water level in the Kremenchuk Reservoir by 2.1 meters, potentially causing flooding in the Chernihiv, Kyiv, Cherkasy, and Kirovohrad regions. A full or partial collapse of the Kyiv dam would create a wave travelling at an initial speed of 50-70 kilometres per hour, with a height of around 10-12 meters. This wave would reach the Kaniv HES in four hours and the Kremenchuk HES in 31 hours. The most severe consequences are estimated from the ensuing destruction of the Kremenchuk HES, as waters from Ukraine's second (now first) largest water Reservoir would devastate the Middle Dnipro and the DniproHES dams, eventually flooding areas of the cities of Kropyvnytskyi, Poltava, and Dnipro and several regions in southern Ukraine.

Overall, a potential "domino effect" in the destruction of dams on the Dnipro River can affect an area of 7,000 square kilometres across eight Ukrainian regions with catastrophic consequences. The flood zone could spread to 495 settlements, 19 cities (among which Kyiv, Kremenchuk, Dnipro, Zaporizhzhia, and Nikopol), and 353 Ukrainian industrial sites. Approximately 11.5 million people might need to be evacuated from the affected areas. Navigation on the Dnipro River would likely be disrupted, as the flood wave would probably destroy most bridges and many water transport facilities along the river (Ryzhenko, 2022).

3.4. Environmental disaster and ecocide

3.4.1. Introduction

While the impact of the Kakhovka explosion deserves particular attention, it is also important that such large-scale events do not detract from the smaller but more numerous incidents that are causing environmental harm on a daily basis in Ukraine (CEOBS, 2023). The damage to nature sustained so far by Ukraine's protected area estate that we know of has been highly destructive and has the potential to be catastrophic. The frontline continues to shift, and with it, the intensity of impacts on nature conservation areas. Timely monitoring of the damage caused is important (Timmins et al., 2023)

In spite of this attention, determining the precise impact on habitats and species remains complex. Ecosystems must be monitored over more than one season, by experts with knowledge of them, yet in many cases ground surveys remain impeded by frontlines, the presence of landmines and explosive ordnance, and the loss of human capacity and equipment. It is possible that, for some sites, the true extent of the damage wrought by the conflict will never be known (CEOBS, 2024).

After the invasion, one of the ecosystems suffering the most from the war is exactly the "main artery" of Ukraine - the Dnipro River. Heavy industry enterprises are built on the banks of the Dnieper, which require electricity and water for their operation. Factories use river water, and the used water is discharged into the Dnipro. Therefore, the question of the ecological state of the river has always been relevant. Before the beginning of the Russian invasion, there were still many problems related to discharges and climate change. The war only exacerbated these problems (Ukrainska Pravda, 2022)

Since the beginning of the war, the Dnipro River, mainly in the southern parts, has been destined to be the frontline of military actions. This is leading to enormous damage to the nature and ecosystems along the river and within the whole Dnipro river basin. According to data gathered by Ecoaction and volunteers, by the end of March 2024, there are around 140 cases of direct Potential impacts on ecosystems from the war. In total, 683 cases of war damage within the Dnipro River basin had been registered, most of them around the southern parts of the Dnipro River - Dnipropetrovsk (373 recorded cases), Mykolaiv (306), Zaporizhzhia (119) and Kherson (91) oblasts. The majority of the registered attacks are on energy infrastructure, industrial enterprises or nuclear safety. All of these had direct or indirect impacts on Dnipro's nature. Due to the hostilities, it is hard to estimate the real impact of the war, but we can clearly point out the most impactful factors and the way they influence nature.

Figure 1. Map of Ukraine depicting the number of war cases per oblast (region)
Author: Elaborated by Ro3kvit and Greenpeace CEE

3.4.2. Estimating war damages to the natural environment

As estimated in 2.1 Ecology, before the war, the Dnipro River basin was home to at least 12 825 species, including over 1100 protected or rare species of animals, plants, and fungi. Most of these species inhabited the Protected areas (Nature Reserve Fund, Emerald Network, Ramsar Sites), which covered 55 018 square kilometres or 18.68% of the river basin. Within the Dnipro River basin, there are 2 Biosphere reserves, 2 Nature reserves, 6 National nature parks and 14 Wetlands of International Importance. Most of these protected areas and species, especially in the southern parts of the basin, suffer from the continuing invasion.

Combining the data from Ecoaction and Eyes on Russia map (Centre for Information Resilience, 2022) shows the concentration of war cases (including military presence) within the Dnipro river basin. Each one of these cases, more or less, had a negative impact on nature. The spatial distribution of the case points clearly highlights the areas with the highest concentration (and probably the most affected parts of the basin) - mainly in the south, which currently is the active frontline, and in the Kyiv region.

There are a number of efforts (see Toplead, 2024; CEOBS, 2024; Ekozagroza.gov.ua) that are trying to estimate the damage to the environment in numbers, measuring the damage in monetary value, species lost, flooded areas or burned forest. It should be noted that the real damage is much bigger than these estimations, as it is almost impossible to gather proper data due to the restrictions of the war. Furthermore, it is impossible to measure effects on nature only with numbers because nature simply does not work this way. For example, when an area is damaged - the size of the territory can be calculated, but it is impossible to measure the effect on nature and how it affects the whole ecosystem.

> “An ecosystem is not just some number of living organisms or some area. It is a system of connections,” — Oleksii Vasyliuk, head of the Ukrainian Nature Conservation Group (in Kyiv Post, 2023)

One thing is for sure – there are a number of factors that are causing ecological disaster within Dnipro river basin. Being part of the frontline, the river and its basin suffers from all various threads to nature that are a result of the invasion.

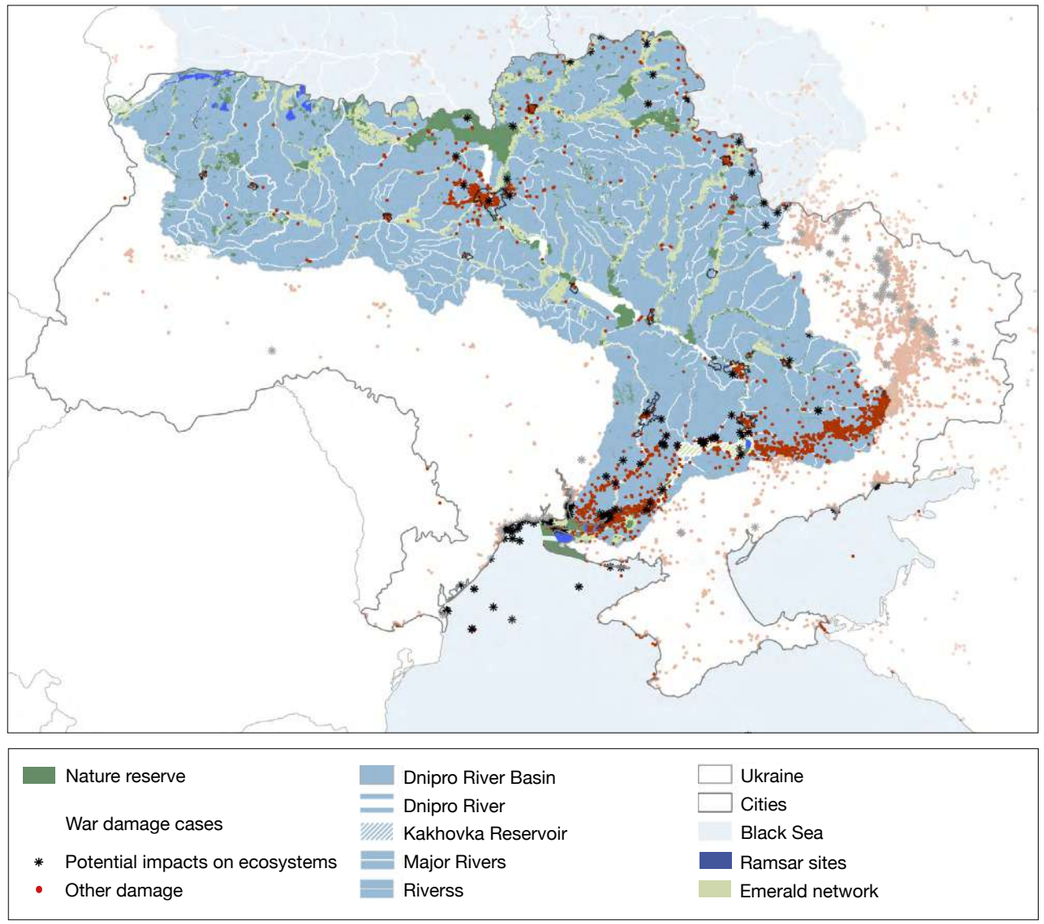


Figure 2. Map of Ukraine depicting the recorded war damage cases, including potential impacts on ecosystems
Author: Elaborated by Ro3kvit and Greenpeace CEE

3.4.3. Major war factors that threaten nature and ecosystems

Impacts from explosive munitions and active hostilities: It has been reported that the Russian Federation is firing around 60,000 artillery shells in Ukraine on a daily basis (Khurshudyan & Sonne, 2022) and Ukraine is firing an average of 7,700 shells per day (Khurshudyan & Hrabchuk, 2023). The immediate physical impact of explosives on ecosystems is highly destructive, causing tree, plant and animal deaths and mass soil erosion (Vasyliuk, 2023).

Pollution from explosive objects: 30% of Ukraine's territory is now potentially mined with explosives, making it the most widely mined country in the world (Save the Children, 2023). In addition to actively mined areas, unexploded munitions (missiles, bombs and shells) now litter much of Ukraine's environment. Unexploded munitions are lethal not only to humans but also to wildlife, which have been blown up, killed, traumatised and wounded by explosions (Polyanska, 2023). They also pose a threat to nature conservation by preventing conservation management activities and deterring nature tourism (Hatton et al., 2001; Vasyliuk, 2023).

Damage from fires: Combat-caused wildfires are usually collateral damage stemming from explosions of artillery, shells, missiles and rockets. Every day tens of thousands of shells explode in Ukraine, each one has the potential to start a fire. In 2022, over 10,000 fires were recorded within 60 km of the frontline, and almost 8,500 fires were recorded in occupied territories (MEPNR, 2023b). Thirteen PAs reported damaging fires from hostilities.

Disruption from heavy military vehicles and war infrastructure: Numerous fortifications, barriers, trenches (Africk, 2023), dugouts, new road networks and heavy military vehicles and equipment have caused physical damage to protected areas, particularly in the east and south of the country. Such infrastructure and vehicle use destroy vegetation and disturb and compact soils and fragile sand and steppe habitats. Ukraine's smaller mammals are particularly vulnerable to this kind of disturbance (Rusin, 2023). Military vehicles also create habitat openings for invasive species (Pashkevich, 2023) and cause animals stress and injury.

Pollution from chemicals: Military activities can release dangerous toxins through emissions from fires at civil and industrial infrastructure sites, pollution from damage to water management systems, fuel and lubricant spills, rocket fuel released at unexploded rocket fall sites and abandoned and burnt-out military equipment degrading in ecosystems (Polyanska, 2023). Explosions also release heavy metals such as arsenic, copper and lead into the environment (Barker et al., 2020), which can accumulate in plants and the bodies of animals, damaging internal organs and the nervous system (Polyanska, 2023; PARKS, 2023) All the aforementioned factors and illustrated cases affected the nature along Dnipro to a different extent. According to experts, the consequences for biodiversity vary due to the specifics of the river as a cascade of reservoirs.

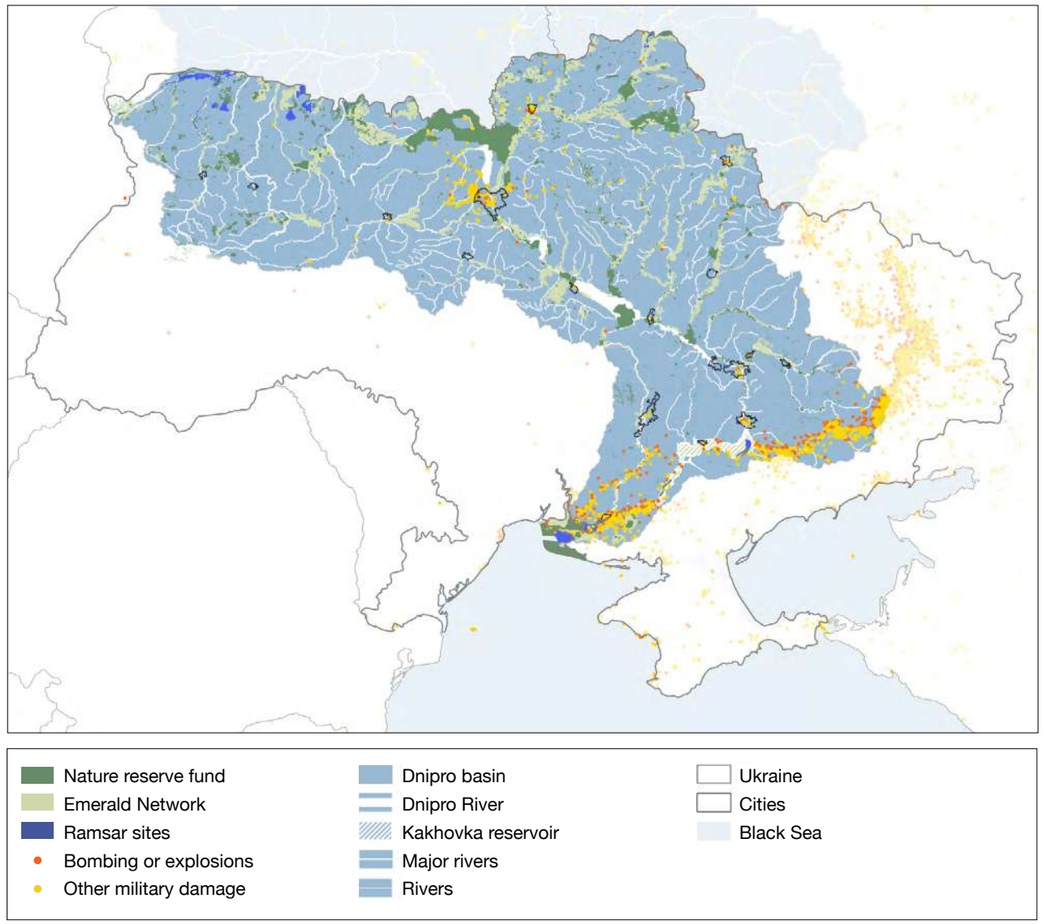


Figure 3. Map of Ukraine depicting the recorded war damage cases, including explosions and other military damage
Author: Elaborated by Ro3kvit and Greenpeace CEE

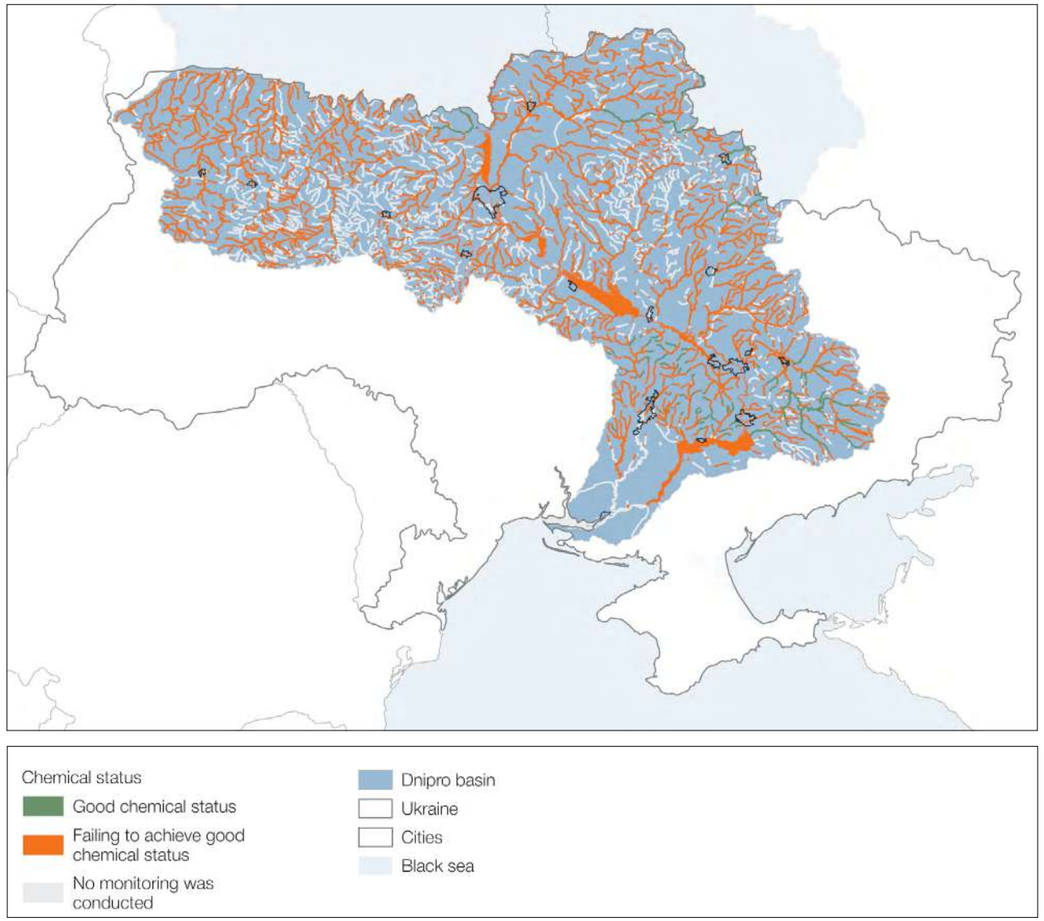


Figure 4. Map of the chemical condition in Dnipro River basin
Author: Elaborated by Ro3kvit and Greenpeace CEE

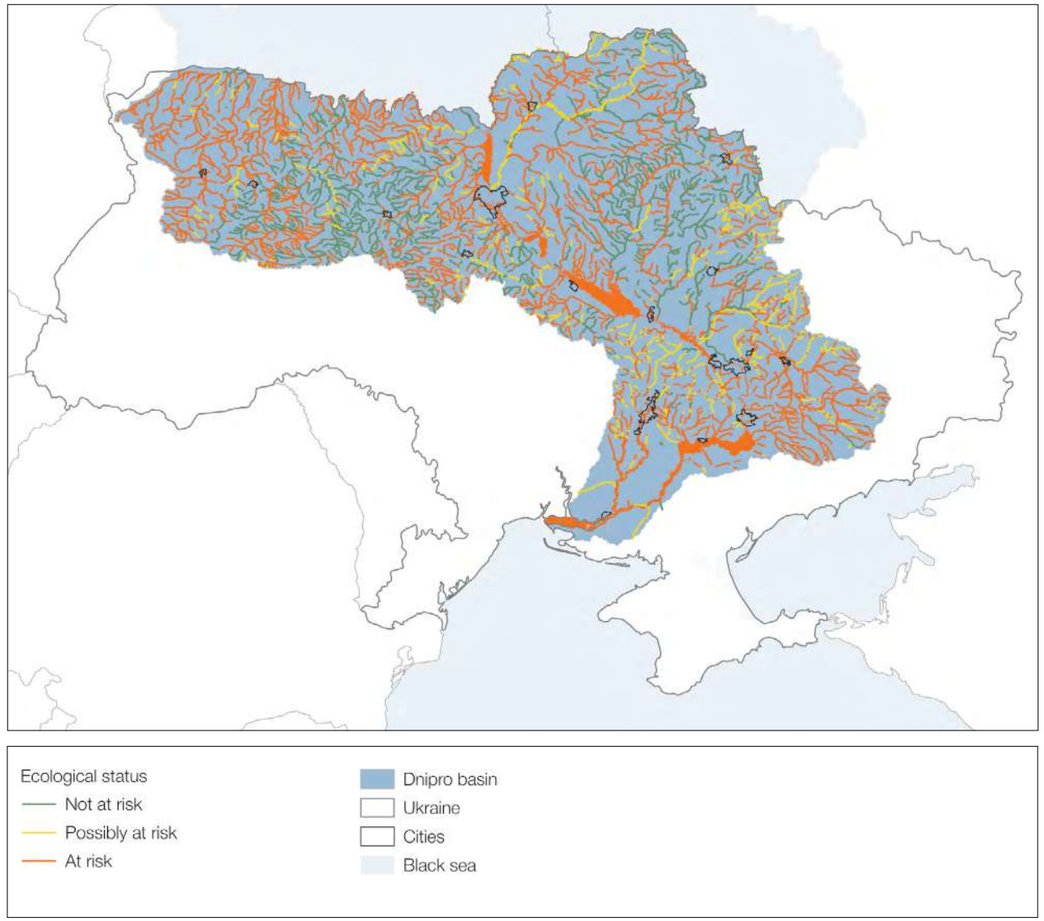


Figure 5. Map of the ecological condition in Dnipro River basin
Author: Elaborated by Ro3kvit and Greenpeace CEE

3.4.4. Evaluating biodiversity losses in the Dnipro River basin

It important to point out that it is very challenging to estimate the biodiversity losses within the Dnipro River basin due to hostilities. Still, some main assumption are made by experts regarding the possible impact of the war on biodiversity. For instance, ecologists of the Ukrainian Nature Protection Group emphasise that "*unfortunately, everything that could be destroyed on the Dnipro River was destroyed during the construction of the reservoirs. The red book river otter and beaver live only in certain areas in the upper reaches of the reservoirs, where there is a natural floodplain and island complexes. Such places did not feel the impact of the war*".

"It is difficult to say that certain species of red-listed animals are threatened with complete destruction as a result of the war. In my opinion, these red-listed species can migrate to safer places - the main thing is that the disturbance factors have a short-term effect." – reflects Serhii Chumachenko. *"If a projectile hits the water and detonates, biota, fish, and birds will die. The entire food chain, from small microorganisms to those that feed on them, can die. But this can only happen locally,"* Oksana Konovalenko emphasises. If a projectile detonates in the reservoir, commercial fish will die. But special species of fish do not live in such places. "Similarly, a beaver will not climb into a reservoir *because there is no place for him to build a house there*," the scientist adds.

"*River ecosystems and aquatic complexes of the Dnipro River have a high assimilation potential for self-regeneration. However, in the end, the waters of the Dnipro River flow into the Black Sea, and factors of cross-border influence begin to work through the Dnipro-Buzka estuary for all countries located on the shores of the Black Sea,*" says Serhiy Chumachenko. (Ukrainska Pravda, 2022).

3.4.5. Major ecocide cases related to the Dnipro River

One example of an act of ecocide caused by deliberate russian terrorist military activity is, of course, the destruction of the Kakhovka Dam, discussed in detail in the previous chapter. Two related cases are described more specifically below.

i. Nyzhnyodniprovskyi National Nature Park

The territory of the National Nature Park "Nizhnyodniprovskyi" (Lower Dnipro) is one of the most valuable natural floodplain-littoral complexes in Europe. Only in the lower reaches, from the Kakhovka HPP to the Dnipro-Bug estuary, the Dnipro River has preserved its relatively natural state. From the beginning of March until November 11, 2022 — the park was under Russian occupation. About 7% of the park was turned into ashes. More than 5,000 hectares of Nyzhnyodniprovsky Park were destroyed by enemy shelling in the first year of the war. Animal and plant life suffered, and more than 5.5 thousand hectares of the park out of 80 thousand were covered by fires. It is important to note that regular fires in the floodplains, caused by enemy shelling, cause irreparable environmental damage, eliminating many animals and plants on the park's territory.

The biggest blow to the park was, of course, the catastrophic flooding. On the day of the explosion of the Kakhovka HPP dam, the park reported that 100% of the territory of the Nyzhnyodniprovskyi National Nature Park was underwater. The rise in the water level led to the mass death of representatives of the animal world and unique plants. There are 60 species of birds under the park's protection, a large percentage of which nest on the park's territory. According to the latest data, 44 fish species are registered within the park, particularly rare species that are disappearing.

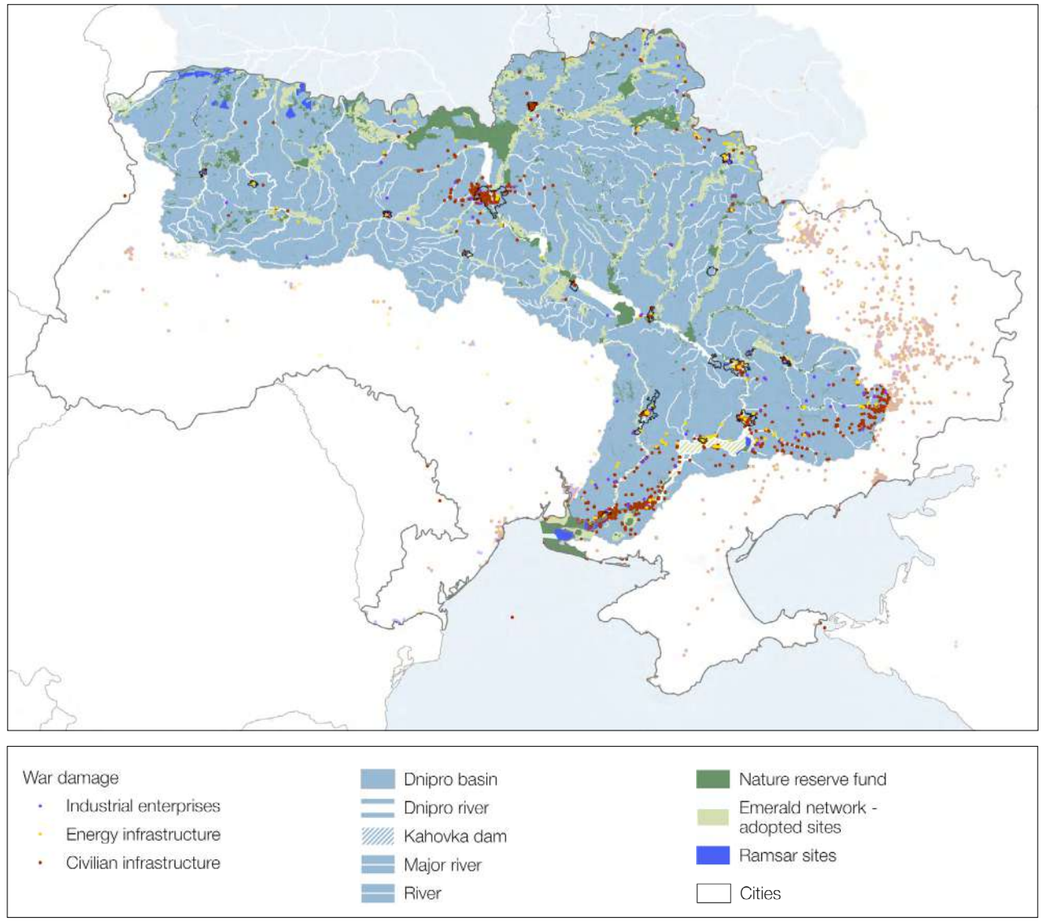


Figure 6. Map of war damage categorised by sector/type of infrastructure in Dnipro River basin. Author: Elaborated by Ro3kvit and Greenpeace CEE

Currently, the presence of 15 species has been recorded, including the valuable sturgeon. As for the flora, approximately 63 species of higher vascular plants were affected, of which 30 are included in the Red Book of Ukraine. The occupiers caused an ecological catastrophe on a global scale, and it is extremely difficult to record all the consequences at the moment because the territory of Nyzhnyodniprovskyi NPP is under shelling (Rubryka, 2023).

ii. Kamianska Sich National Park

Kamianska Sich National Park is a steppe, more than 50 kilometres of the Dnieper coastline, a place of protection for more than 90 species of rare animals. The park was occupied on March 9. For eight months, it suffered from the Russian occupation, and now - from shelling from the left bank of the Dnieper, where the enemy army was driven away by Ukrainian soldiers. Thanks to satellite analysis, it was determined that almost 635 hectares of valuable areas where vulnerable red-listed species were growing had burned.

From February 24 to October 18, the fires destroyed rare plants within the park, including Scythian gorse (633 specimens), rough hemlock (402), hairy hemlock (832), Lessing's hemlock (2384), and Ukrainian hemlock (456) (NRFU, 2022). I think this entire territory can potentially be mined," says Skoryk. "*It is better to be insured because this human life is the most valuable thing in this world*." The maps of the State Emergency Service completely confirm Skoryk's words — the de-occupied territory of the National Park for dozens of kilometres around is considered potentially explosive.

According to the botanist Ivan Moisienko, the steppe may never become the same as it was before the war: it takes hundreds of years and a change of successions (that is, a gradual change of the ecosystem) to reach the state that was previously in the untouched territories. When the shells hit the river, some of them explode, destroying the flora and fauna of the water bodies and polluting the water with chemicals. The part of the projectiles that do not detonate remains at the bottom of the river, creating a threat for decades because underwater demining is a costly and challenging procedure. After the detonation of the hydroelectric power station, the Kakhovka reservoir almost completely silted up — only a thin strip of the Dnipro River remained.

"*This is the end," Skoryk comments on the situation. "The end of aquaculture, the end of the Kakhovka Sea. This is a huge disaster. "The real consequences will come later when it dries up: high temperatures, winds, climate change. In addition, the metals that have been dumped into the Kakhovka reservoir for 70 years from Dniprorudne, Marhanets, Nikopol, Kryvyi Rih, and Enerhodar will rise into the air, and Ukrainians will inhale all this with our lungs.*" (Rubryka, 2023).

3.4.6. Concluding thoughts

War is destructive not only to humanity but also to nature. There are a lot of various aspects of the invasion that are destructive to various components of nature, like forests, biodiversity, ecosystems, and soils. One of the most important aspects that connects all of the aforementioned is the one that provides life - the water. Unfortunately, burned forests, polluted soils, the extermination of biodiversity, and the destruction of ecosystems affect in some way the quantity and quality of natural resources.

It is currently impossible to estimate the size of the ecological disaster within the Dnipro River basin. First, due to the continuing war, access to many protected areas and zones along the Dnipro River does not allow scientists to conduct research. Second, it is easier to calculate the losses in numbers at some point, but this method does not represent the real losses to nature and ecosystems because they are not measurable in figures.

Last but not least, the consequence of the invasion and all the destruction will last and affect the basin for many years, even after the end of the war. Toxic pollution will gradually soak up through the soils into groundwater; invasive species will dominate areas with destroyed vegetation; landmines will restrict the availability for scientists to access (protected) areas, estimate the real consequences and conduct conservation activities; untreated urban waste will be leaked into rivers until new treatment facilities are built, toxic water pollutants will be transported by water, settling and accumulating in various places along the river. These and other unexpected consequences (some of which may be positive) will significantly change the expression of nature within the Dnipro River basin.

Along with the ecocide caused by the 3.3. Kakhovka Dam Destruction and the devastating consequences for the Lower Dnipro River region, there is one major ecological disaster that has not been touched upon enough - this is the deteriorating quality of water and increasing water pollution due to the hostilities. Before the invasion, surface water bodies in the Dnipro River basin suffered from various diffuse and point sources of organic, biogenic and pollution from hazardous substances. Due to the huge anthropogenic pressure in the basin, active agriculture, the lack of sewage systems and water treatment plants, numerous big industrial enterprises and other reasons, the chemical status of the water for the majority of surface water bodies in Dnipro basin failed to achieve good quality. This conclusion is based on data provided by the Water Agency. The dataset combines monitoring with aggregated data in order to illustrate this aspect of water quality.

Furthermore, within DRBMP, 2023, the Water agency assessed surface water bodies according to the risks of failing to achieve good ecological status/potential. The ecological status of Surface Water Bodies (SWB) is based on biological quality elements (phytoplankton, macrophytes, phytobenthos, macroinvertebrates, and fish) and supporting physicochemical factors (nutrients, oxygen condition, temperature, transparency, salinity) as well as river basin-specific pollutants, and hydro-morphological quality elements (DRBMP, 2023). Parts of 833 out of all 1311 rivers in the basin are estimated to be at risk of achieving good ecological status. Unfortunately, most of the war activities contribute even more to the already poor water quality in the Dnipro Rive. The consequences of this are described in the next chapter, 3.5 Water Disruption and Pollution.

3.5. Water disruption and pollution

3.5.1. Water quantity: Ukriane's water infrastructure under russian attack

The ongoing war in Ukraine has inflicted immense human suffering, and among the critical resources under threat is water. Both natural water quality and quantity, as well as associated water infrastructure, have been severely impacted, jeopardising the health and well-being of millions of Ukrainians.

As mentioned above, water infrastructure has been repeatedly targeted by Russia's military forces — a violation of international laws. The conflict has already wrought untold damage. Due to the ongoing war, the water supply and sanitation sector has experienced losses and has struggled to provide essential services in extremely difficult circumstances. Damage to raw and treated water and wastewater pumping stations, reservoirs, and drinking water distribution networks has led to the disruption of water supply across the country. The mass drone and missile attacks on critical civil infrastructure at the end of 2022 and the beginning of 2023 significantly affected WSS service provision. WSS infrastructure was damaged both in territories still under government control and in those not under government control (World Bank, 2023). At the same time, the rivers and irrigation channels that both militaries use as natural fortifications "have also become a burial place for military objects," like ammunition that can leak heavy metals and toxic explosives, with impacts that may last for decades (NYTimes, 2023).

Another important source of disruption is the ongoing power outages and intermittent electricity supply, which have significantly affected these services. Water and wastewater facilities are all highly dependent on and require constant electricity supply. Beyond direct physical damage to water-related infrastructure, the disruptions to power grids, communication networks, and SCADA systems affect the functionality of water treatment plants, pumping stations and distribution systems, creating additional challenges in ensuring safe water access. Despite the ongoing efforts of emergency and communal service providers, millions of Ukrainians continue to receive intermittent WSS services (World Bank, 2023).

Millions of Ukrainians face daily struggles to access clean drinking water, particularly in heavily contested areas. UNICEF reported in April 2022 that 1.4 million people in eastern Ukraine had no running water, while 4.6 million had limited access. The destruction of the Kakhovka dam in June 2023 and the subsequent loss of the Kakhovka Reservoir left over 1.25 million people and 300,000 children without stable water supplies, aside from the flooding impacts (Save the Children, 2023). While likely the most significant, it is, however, just one of many examples of Russia's direct impact on water infrastructure. The research briefing by Nature Sustainability reported in early 2023 that at least 12

Figure 1: Residents fill up bottles with fresh drinking water, s water supply was disrupted due to russian military attacks and the destruction of the Kakhovka dam, June 2023. Author: unknwon; Source: DSNS Ukraine

pumping stations, six dams, three wastewater treatment plants, and two filtration stations have been damaged or destroyed (Shumilova et al., 2023b).

Intensive military activities near rivers and reservoirs increase the risk of over-extraction and depletion of water resources. This jeopardises not only drinking water availability but also irrigation for agriculture, impacting food security in the long run, as discussed extensively in 3.3.

Kakhovka dam destruction. While Ukraine is working to replenish water levels on the Dnipro River, they still lag considerably behind normal levels. Large reservoirs along the Dnipro River are of particular concern, as they are vital for water supply, energy generation and energy security (nuclear power plant cooling), sustaining agriculture and food exports, but also seasonal flow regulation (Shumilova et al., 2023a; NYTimes, 2023).

3.5.2. Water quality: The humanitarian and environmental consequences of the russian aggression

Direct attacks on wastewater treatment plants and pipelines have also led to the release of untreated sewage and industrial waste into waterways, significantly increasing pollution levels. The study in Nature showed how, in the first months of the war alone, Russian attacks on wastewater treatment facilities resulted in widespread pollution of waters (NYTimes, 2023). The flooding of abandoned coal mines further threatens groundwater purity.

A study published in “The Journal of Occupational Medicine and Toxicology” estimates that 20.7 billion cubic meters of untreated wastewater have been discharged into surface waters since the war began. Moreover, the consequences of war actions bring additional risks of chemical contamination. Munitions and explosives used in the conflict release harmful chemicals into the environment, contaminating water sources. The destruction of cities and industries (as well as chemical tank storage) contributes to Ukraine’s pollution impact. Heavy metals, nitrates, and other toxic substances pose long-term health risks to those consuming or using contaminated water.

Lack of access to clean water and proper sanitation increases the risk of waterborne diseases such as cholera, dysentery, and typhoid fever. These diseases can have devastating consequences, particularly for vulnerable populations. In addition, clean water is essential for hospitals, dialysis facilities, and healthcare facilities.

At the same time, in a more global context, water shortages impact agricultural production, potentially leading to food insecurity and price hikes. This can exacerbate existing humanitarian crises and threaten the livelihoods of millions of Ukrainians but also whole populations that depend on the export of Ukrainian agricultural products. In the long term, the war’s impact on water quality and quantity poses a serious threat to ecosystems and biodiversity, as discussed in the previous section 3.4. Ecocide and ecological disaster Pollution and habitat destruction can have lasting negative consequences for the environment and future generations.

Overall, the ongoing war in Ukraine has had a devastating impact on the country’s water resources and infrastructure. Millions face daily challenges in accessing clean and safe water, and the long-term environmental consequences are far-reaching.

Figure 2: A photo of the flooded streets of Kherson on June 7, 2023, one day after the destruction of the Kakhovka dam by the russian military. At the centre of the photo a rubber safety boat evacuating a 14 year old boy, his grandparents and their dog. Author: unknwon; Source: DSNS Ukraine

3.5.3. Water scarcity and climate change

At the same time, while the impact of the war has been unprecedented in its devastation, it is important to note that water problems in the Dnipro River have also been identified before the beginning of the full-scale war, with some alarming observations on the topic of water quality, water pollution, but also some concerns about water quantity. While about 75-80% of the water supplied to consumers is taken from surface sources (rivers) in Ukraine, the country ranks 32nd among 40 in terms of drinking water provision in Europe, which puts it on the list of countries threatened by water scarcity (WAREG, 2023). Indeed, while the volume of water withdrawn from the Dnipro River Basin for various human needs is huge, it is worth noting that the water supply level of the Dnipro River Basin is 1.75 thousand cubic meters per person per year, which is just above the minimum threshold as determined by the UN classification (Source).

Climate change

A major contributing factor to the challenge of water scarcity in Ukraine is climate change. Climate change is a major global problem that threatens the existence of both humanity and biodiversity on Earth. The area of glaciers is decreasing, sea levels are rising, and strong storms, tornados, abundant floods, and droughts have become more frequent. These changes affect nature but also significantly affect the lives and health of people all over the world, and the Dnipro River basin is no exception. The water-heat balance of river basins is too sensitive to climate change. An increase in air temperature and a change in the nature of precipitation affect not only the hydrological regime of rivers but also the general reserves of water resources.

Some of the pressures of climate change are already being felt today, making predictions for the future even more alarming. Various climate projections for the 21st century have been conducted to access possible scenarios, among others, for the availability and quantity of water across various regions around the world. With average annual temperatures across regions expected to rise by 2-5°C, according to the climate models of the Representative Concentration Pathways (RCP), the Dnipro River, too, will inevitably see changes coming.

Based on the softest of four scenarios (RCP 2.6.), which foresees reductions in greenhouse gas emissions in line with the Paris Agreement, the Dnipro River Basin is expected to see a significant decrease in water level from 2041-2070 compared to the period from 1981 to 2010, with seasonal drops of 13-19% in April-May and 9-11% drops for the summer period. In comparison, the hard scenario (RPC 8.5), which does not take into account any climate adaptation or mitigation measures, projects greater water scarcity with decreases in water runoff reaching 24% in May and 15-17% in the summer period.

For the period of the distant perspective (2071-2100), according to the RCP 2.6 scenario, the largest flow decrease is expected in May by 11%, in the summer by 8-9%, and in the winter months, on the contrary, some increase in flow is expected — up to 7-8% (February-March). According to the RCP 8.5 scenario, the water level of the rivers will decrease in all months of the year. (Ecoaction, 2021; Didovets et al., 2020). Other studies show that the Dnipro River basin forest zone could experience a reduction in runoff of up to 29% by 2030-2040. For the steppe regions of Ukraine, runoff will decrease to 40% by 2030-2040, and by 2070-2080, river discharge may stagnate for extended periods. (Horbachova, 2017).

Even before the destruction of the Kakhovka Dam, since Russia's occupation of the southern regions of t Ukraine in February 2022, the barbaric withdrawal of water from the Kakhovka Reservoir for the supply to the occupied Crimea has already led to a sharp drop in the water level in the Dnipro River. And infrequent rains do not compensate for these losses. In July 2023, the reservoirs of the Middle Dnipro replenished by only 45% of the norm. The forecasts for the future are disappointing. The climate in Ukraine will have long periods without rains, during which there will be a drop in the groundwater level, drying up of small rivers and wells in households. According to projections, a significant reduction in local surface runoff in rivers in the Kherson, Odesa, Mykolaiv, Dnipro and Zaporizhzhia regions is possible in the periodafter 2041. This could lead to a growing shortage of fresh water over the next 30 years, and Ukraine may even have to start importing drinking water after 2050 (Ecopolitic, 2022).

Outdated water treatment infrastructure

The issue of water scarcity is further aggravated by the fact that the use of natural water resources in Ukraine is also highly inefficient due to outdated or neglected technical infrastructure in the water management sector. For instance, the percentage of water loss in the residential and municipal sector is 25.3% of the intake in the Dnipro River basin, amounting to 277 million cubic meters of water (DRBMP, 2023).

The outdated water supply and purification technologies, the absence of water monitoring systems, the ineffective state control over water resource protection, and imperfect water legislation are exacerbating the issue of inefficient resource allocation and use. To add on, the destruction and damage to water infrastructure as a result of Russian military actions since the beginning of the full-scale invasion in 2022 have put the water supply sector in an even worse situation, as water supply and sewage plants are unable to cope with current loads and often do not meet modern requirements for water and wastewater treatment (WAREG, 2023).

3.5.4. Water pollution

“The Dnipro river is heading for ecological catastrophe”

The many reports and observations made in the last decade lead to a clear conclusion — the Dnipro River is no longer a natural source of clean freshwater as described by Herodotus and our many ancestors throughout the centuries and millennia. In 2021, a report in Ukraine’s parliament branded the ecological situation of the Dnipro basin as “catastrophic”. Kyiv’s authorities had to ban swimming in the river due to healthcare concerns, as the river turned unusually green due to algae caused by an increase in the concentration of phosphates. Ukraine’s Minister of Ecology, Roman Abramovsky, estimated that 6,000 tonnes of phosphates from all sources were dumped into the river that year – ranging from dishwater detergent to pharmaceutical drugs and industrial waste (Mamo, 2021).

A 2021 audit by the Accounting Chamber of Ukraine also alarmingly identified 161 pollutants in the surface waters of the Dnipro River, including the herbicide atrazine and metals cadmium and nickel, which pose both ecological and health threats for humans and the ecosystem in general (The Accounting Chamber, 2021; EcoHubMap, 2021). Another monitoring screening for pollutants in the Dnipro River Basin conducted in the framework of the EUWI+ project similarly revealed more than 67,000 pollutants, including pesticides, pharmaceuticals and heavy metals in sampled concentrations, significantly exceeding EU standards (EU Neighbourhood East, 2021).

Worries about water quality in the Dnipro River have existed before that, too. In 2017, a Ukrainian independent media resource, Texty, published a study with a long but speaking title: “Dams, warming, and phosphates are turning the Dnipro into a stagnant ditch. How and when did cyanobacteria take over the Dnipro? Why do fish throw themselves onto dam turbines? Why are rivers losing their self-purification ability, and how can we make dead water alive again?” (Texty, 2017). The answer, of course, is complex. In part, this phenomenon is caused by the transformation of Dnipro’s natural flow into a series of stagnant water reservoirs, in part because of the rising temperatures. However, an important cause of water pollution inevitably comes from humanly-caused waste release.

In total, water users discharge as much as 3213 million m3 of wastewater into the surface waters of the Dnipro River Basin, which constitutes 60% of the total volume of wastewater discharge in Ukraine (DRBMP, 2023). The vast majority of this wastewater — that is, more than 2241 million m3 — is discharged by industry, followed by residential and municipal water users with 756 million m3 of wastewater, agriculture — 173 million m3, and another 41 million m3 by transportation and other sectors.

A significant portion of the wastewater volume (66%) is discharged without treatment, another 17% is polluted wastewater, and only 14% is treated according to regulatory standards at specialised water treatment plants (DRBMP, 2023). The pollution of the Dnipro River is uneven and increases from north to south. In the upper reaches, around Kyiv, the level of water pollution is lower due to the natural flow of water and the significant inflow of clean water from the Desna River. However, pollution significantly increases in the lower reaches (Suspilne, 2021).

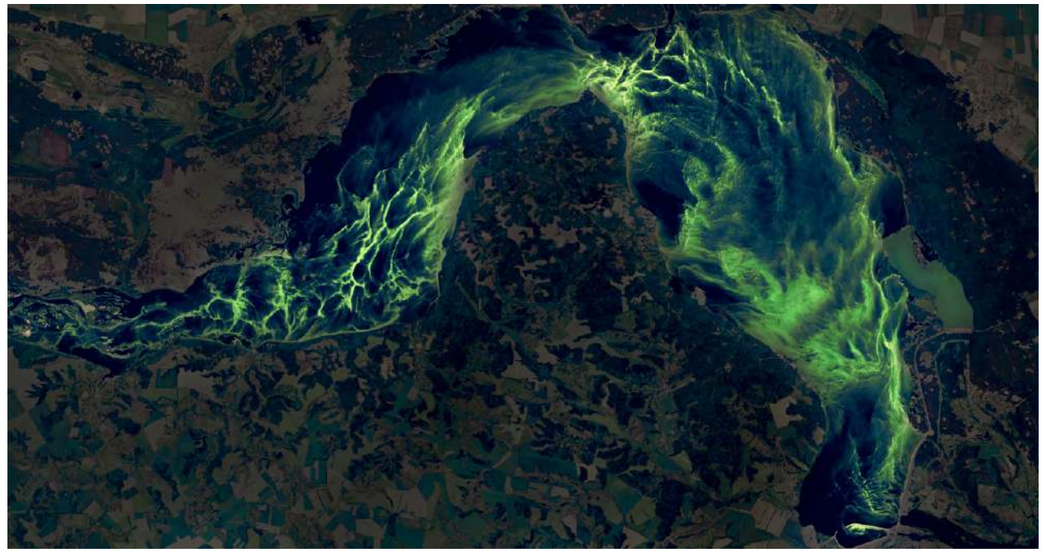


Figure 3. Satellite image of the Kaniv Reservoir covered in green/blue algae in the summer of 2017.
Author: unknown; Source: Accessed via Texty.org.ua

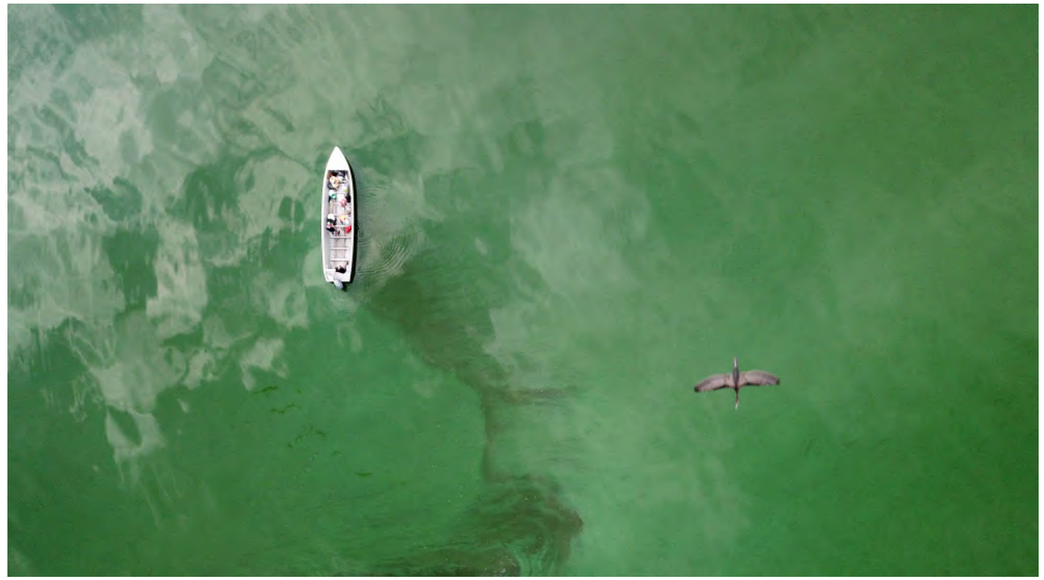


Figure 4. A boat leaves a trace in the water as it crosses green algae in the Dnipro River
Author: Olena Bilous; Source: Provided by the author

Interviewing
Olena Bilous

Scholar, senior researcher at the Institute of Hydrobiology
From Kyiv
Lives in Vienna

I grew up in the Troyeshchyna area of Kyiv, where my parents and I would spend nearly every weekend by the river. We enjoyed time along the Dnipro and its tributaries, such as the Desna and Desyonka. My father taught me how to swim and took me on walks along the promenade. Some of my most vivid memories are from when he brought me along to work meetings held on a steamer sailing the Dnipro.

Today, I work as a senior researcher at the Institute of Hydrobiology, dedicating my life to studying the processes that occur in aquatic ecosystems, with a particular focus on algae. My research deals with ecological issues, specifically the extent to which algae can be used as bioindicators to assess the quality of natural water bodies. Currently, my colleagues and I are working on a publication about the impact of military operations on the Irpin River basin.

As we navigate the realities of war, the fate of the Dnipro will undoubtedly be greatly affected.

In 2021, we had an incredible expedition studying how macrophytes can reduce the amount of algae in the Dnipro reservoirs and whether there are correlations and interconnections between them. We conducted an extensive study of the Kyiv and Kaniv reservoirs, with the project intended to last two years. Unfortunately, due to the war, it only lasted one year with a single full field trip. In 2022, my colleagues continued to take samples, but on a smaller scale, as some parts of the reservoirs were no longer accessible.

As an environmental scientist, I am deeply concerned about the state of the river. When people refer to the Ukrainian part of the Dnipro, they don't say "river" but rather "cascade of reservoirs."

It's a painful reality that we cannot escape, especially as the number of hydroelectric power plants is expected to grow due to the war-induced electricity shortage. However, it is still possible to implement measures to protect the river. I'm pleased that we have a state program to reduce phosphates in detergents, aligning with European standards.

When combating water blooms, we should focus on preventing the problem altogether rather than dealing with ongoing consequences.

We must treat water as a valuable resource and reduce its use when unnecessary.

For example, European practices encourage reducing the number of lawns by choosing more environmentally friendly approaches and using grasses that require less watering. There are many measures that can be taken, but they should be accompanied by public education.

As our country has clearly chosen a pro-European course, it is crucial to strictly adhere to European legislation, strengthen the protection of water bodies, and adopt a more scientific and reasonable approach to water use.

Everyone uses the river in some way, as people are naturally drawn to water. Barbecues by the river are a beloved Ukrainian tradition in May. Of course, we also use it daily simply by living in Kyiv; when we turn on the tap, we use pre-treated water from the river. Additionally, the Kyiv and Kaniv reservoirs are home to a large number of commercially harvested fish. It's unfortunate that at various scientific meetings abroad, such as in Austria, Ukraine is often mentioned in the context of problems caused by the sturgeon-fishing business, which has essentially destroyed the sturgeon population in the Dnipro River. As a scientist, I know that sturgeons have disappeared from the Dnipro, and it's a shame. I hope they can be reintroduced, at least in the lower part of the river, although I'm uncertain if this will happen.

People should be more respectful of water use and refrain from polluting the river.

Despite the efforts of environmental services, there are still instances of improper discharges into the river, and there are insufficient water protection strips to prevent washouts and the influx of organic matter from fields into the reservoir. More funding should be allocated for environmental monitoring, and salaries should be increased for those who control it to prevent corruption and unauthorized dumping into the river. Primarily, I would focus on protecting the river from all the negative elements that can contaminate the water. Moreover, we need to educate the public.

Everyone should understand that if we pollute the river now for short-term gain, nothing will be left for our children and future generations.

i. Pollution by communal enterprises

The presence of major cities like Kyiv, Dnipro, and Zaporizhzhia along the riverbanks exacerbates the issue of water quality, as waste from these cities and their residents constitutes a significant source of pollution. In fact, the residential and municipal sector is the primary polluter of the basin, accounting for 77% of polluted wastewater discharge (DRBMP, 2023). While some existing treatment facilities and technologies used for purification (mainly biological methods) fail to achieve the required quality standards for wastewater, other waters are released into the Dnipro River without treatment at all. Municipal wastewater is the primary source of pollutants in surface water bodies (>50%). Surface water pollution by organic substances and nutrients is principally attributed to point sources, among which municipal wastewater plays the dominant role. The main load of organic substances and nutrients is caused by the wastewater discharges of large urban centres with a population exceeding 100,000 inhabitants; 89% of such cities are located within the sub-basins of Middle Dnipro and Lower Dnipro (Osadcha et al. 2021). The four largest polluters in the Dnipro River basin are among the top 20 polluters in Ukraine. These include municipal enterprises Kyivvodokanal, Dniprovodokanal, Aulsky Vodovidvid of the Dnipropetrovsk region and the Miskvodokanal (City Water Utility) in Kamianske, which together account for 63% of the discharge of polluted wastewater in the Dnipro River Basin (DRBMP, 2023).

ii. Industrial pollution

In addition to pollution caused by urban residential and municipal discharge along the Dnipro River, industrial pollution is also a significant factor contributing to the degradation of the river. The majority (70%) of water discharged into the surface waters of the Dnipro River comes from the industrial sector. While withdrawing 2891 million cubic meters of water (equivalent to 44.3% of all water withdrawn), the industry discharges back 2242 million cubic meters. Of those, the majority is used by the energy sector, including for cooling, and is returned back to the Dnipro River. In total, 3.5% of the total volume of water discharged by the industry is polluted (DRBMP, 2023). An analysis of contaminated water discharges to the surface water objects from industrial enterprises showed that 146.1 million cubic meters of contaminated water were discharged in 2017. Of these, 24% were discharged without purification, while the remaining 76% were dropped as insufficiently purified water.

The largest volumes of polluted water discharges come from the enterprises of ferrous metallurgy, which makes 124 million cubic meters, or 85% of polluted water discharge from all enterprises. For instance, ferrous metallurgy is responsible for 51% of all mineral salt discharge (a total of 95,130 tonnes in 2017). In particular, the excessive content of mineral compounds of nitrogen and phosphorous leads to the eutrophication of water, which is dangerous for the ecosystems. In 2017, industrial enterprises discharged 3,713 tonnes of nitrogen in total and 246.5 tonnes of phosphorous in total. Additionally, in the same year, an analysis of the discharge of organic substances identified 811 tonnes of BOD and 4,717 tonnes of COD by industrial enterprises. The main share of contamination is made by enterprises of ferrous metallurgy, as well as chemical and petrochemical industries (EUWI+, 2020, p.28).

Industrial sewage wastewater often contains a considerable concentration of trace elements, many of which possess toxic properties. The majority of these components in industrial wastewater consist of compounds containing heavy metals. Among the discharges of heavy metals, the dominating compound recorded was iron — 96% (79.2 tonnes), the majority of which (59.4 tonnes) was discharged by ferrous metallurgy enterprises. Other heavy metals found in water samples include aluminium (0.24 tonnes), cadmium (0.09 tonnes), cobalt (0.002 tonnes), manganese (1.53 tonnes), nickel (0.252 tonnes), lead (0.055 tonnes), total chromium (0.056 tonnes), chromium 6+ (0.015 tonnes), zinc (0.845 tonnes), copper (0.57 tonnes). The largest number of industrial enterprises, particularly ferrous metallurgy enterprises, is concentrated within the Dnipropetrovsk and the Zaporizhzhia regions (EUWI+, 2020, p.28-29).

Less significant but nonetheless existent is the pollution created by the transportation sector. Water users in the transport sector discharged 6.718 million cubic meters of return wastewater into surface water bodies, of which only 0.339 million m3 were polluted. Other types of water use withdraw water in an amount less than 0.1% of the total water intake volume in the river basin (DRBMP, 2023).

iii. Agricultural pollution

A third important source of pollution, which is perhaps less acknowledged, is agriculture. Less acknowledged it is due to the difficulty in tracking and monitoring it: with industrial or urban pollution it comes from a pipe or a certain physical point in space, while with agriculture, contamination is distributed across the river basin, leading to a so-called 'non-point' or 'diffusive pollution'. The main causes of agricultural pollution are the use of pesticides, artificial fertilisers, and agrochemicals, as well as the industrial amounts of animal waste (Mamo, 2021).

In total, in 2019, agricultural water users discharged 173.2 million cubic meters of wastewater into surface water bodies, which constitutes 5.4% of the total water discharge volume in the basin. The main portion (80%) of the wastewater is considered normatively clean without water treatment (DRBMP, 2023). However, as mentioned above, agricultural pollution can be more subtle to track and often does not account for the various forms of agrochemical products. To acknowledge the scale of the problem, it is interesting to look at the data provided by the EUWI+ 2020 technical report on the characteristics of the Dnipro River Basin. For instance, in 2017, 8,222,300 hectares of agricultural land were fertilised, equivalent to 28% of the Dnipro River Basin area, ranging from 223,000 hectares to 1,177,500 hectares in the different regions.

"The share of mineral fertilisers is predominant. Among the mineral fertilisers, nitrogen fertilisers (~80%) are the most frequently used ones – from 222,300 to 1,153,300 ha, depending on Oblasts. Mineral and organic fertilisers represent an average input of 101kg N/ha (43-239 kg N/ha by oblast), 23 kg P2O5/ha (10-82 kg P2O5/ha by oblast), 700 kg organic fertilisers/ha (from 100 kg/ha to 2 T/ha by oblast). The Chernihiv and Poltava oblasts, which are fully located within the Dnipro basin, will play a major role in surface water contamination with mineral fertilizers. In addition, the water-physical characteristics and soil texture of the Chernihiv Oblasts are the most conducive to fertilizer infiltration in the lower horizons and their subsequent migration with lateral runoff. Despite being one of the smallest parts of the Lviv Oblast in the Dnipro basin, the developed livestock sector will contribute to the largest input of the oblast to water pollution due to organic fertilizer" (EUWI+, 2020, p.25).

At present, the agricultural industry, particularly farmers, is almost unregulated by the state. Consequently, the excessive use of agrochemicals and mineral fertilisers affects the condition of water. Furthermore, even the minimal restrictions that were in place during Soviet times are currently absent, and the adoption of new ones is often blocked at the highest level (Suspilne, 2021).

Overall, we can see that the issue of water quality is facing a number of significant limitations. The discharge of polluted, contaminated, untreated or badly treated water back into the Dnipro River has a multifaceted dimension which involves Ukraine's agriculture and industry, essential for the economy, but also the day-to-day water consumption by households and the municipal residential users. While it would likely be an overstatement to say that most tap water is toxic in Ukraine, it is true that, according to some assessments, water quality does not meet the state standards and hygiene norms. For instance, a study by Shulyak et al. on tap water in Volyn, Chernihiv, Kyiv, Sumy, Cherkasy and other regions concluded that water does not contain enough essential minerals, such as manganese, iron, copper or fluorine (Shulyak et al., 2021)

3.6. Disruption of navigation and trade

3.6.1. Disruption of Ukraine's economy: General context

In 2022, as a result of Russia's full-scale invasion, Ukraine's gross domestic product (GDP) fell by almost 30%. According to the Ministry of Finance, this is the largest loss in economic activity that the country has experienced since gaining its independence in 1991 (Reuters, 2023). This is, of course, not the first recession that the country has encountered in the last decades, as the recent COVID-19 pandemic in 2020 and the 2014 russian illegal occupation of Crimea and military aggression in the Donbas also resulted in significant economic losses (CSIS, 2023). However, these losses are incomparable to the severity of the most recent invasion. As reported by the World Bank, this invasion has caused "staggering losses to Ukraine's people and economy, setting back 15 years of development gains and increasing poverty" (World Bank, 2024).

Many people visiting Ukraine are often surprised to find that in the cities and towns away from the frontline, life looks normal. Despite the war, most people have returned home. Parents are sending their kids to school, and shops, restaurants, and businesses continue to be open (World Bank, 2024). Of course, all of this is possible due to the strong resilience of the Ukrainian Army holding the frontline, but in part, it also reflects the "stronger-than-expected recovery and steadfast reform momentum", as noted by the IMF in a report dated December 2023 (Atlantic Council, 2024). But, while in 2023, economic growth surpassed expectations, the road to full recovery remains long and uncertain (European Parliament, 2024).

As the war drags on, Ukraine's current and future financing needs remain immense (World Bank, 2024). "The Rapid Damage and Needs Assessment (RDNA3), released in February 2024, estimates that the cost of reconstruction and recovery stands at $486 billion over the next decade and combines both needs for public and private funds", with the highest needs falling in housing, transport, commerce, industry, agriculture, energy, social protection and livelihoods, but also explosive hazard management, among others (World Bank, 2024b). As the country remains at war, its economic outlook remains conditional on donor support.
The latter sections provide a more detailed account of the disruptions to the economy, industry, agriculture, fishing, but also tourism and recreation, that resulted from the Russian military aggression.

3.6.2. Implications for navigation and trade

Throughout the early months of 2022, the navigation on the Dnipro River was paused due to the planned works on the six sluices of the dams as part of the modernisation of river navigation in the framework of the National Found of Inland Waterways (Ukrvodshliah, 2022). On the eve of the Russian full-scale invasion, river navigation was continuing to develop. The planned beginning of navigation was moved up from March 31 to March 1 in response to the high demand for the river transportation of goods. On the day before the full-scale invasion, February 23, 2022, a decision was made by the Cabinet of Ministers to cancel the fee for passing watergates, with the intention to incite this sector of transportation. On the same day, a message was also posted on the official website of the National agency Ukrvodshliah, announcing a briefing scheduled for February 24 to present further steps regarding the development and modernisation of river waterways and navigation (Ukrvodshliah, 2022). The briefing was, of course, cancelled.

With the beginning of the Russian full-scale military invasion, river navigation was significantly affected and disrupted. Since February 24, 2022, martial law has been in effect in Ukraine, which imposed several significant restrictions on people's rights and freedoms. Among these restrictions is the navigation of vessels on waterways. Since February 2022, the various local and regional military administrations adjacent to the Dnipro River issued decrees banning the navigation on the Dnipro River for the period of martial law, which continues to this day (DARG, 2022). Despite the special navigation regime defined by martial law, some navigation continued as some vessels were able to renew their commercial activity. While the procedure might differ across different administrative boundaries, special permission can and should be obtained to carry out the movement of vessels on the navigable sections of the Dnipro River (Ports UA, 2023). However, safety restrictions were not the only, and definitely not the worst, challenges faced by riverine navigation.

Those areas affected by direct military activities suffered the most. Back in 2022 and 2023, whilst Kharkiv was still under russian occupation, the russian navy was ordered to mine approaches to the mouth of the Dnipro River along with the ports of Odesa and Ochakiv in order to block grain exports. The Dnipro-Buh Estuary, still dividing Ukrainian-controlled territories from those occupied by russia, remains hazardous due to the possibility of mines. So, the lower reaches of the Dnipro River and the Delta remain. The flood that resulted from the 3.3. Kakhovka Dam Destruction brought all sorts of hazardous debris and military waste, including mines, along the river and into the

Black Sea, which made the area unsafe. The extensive placement of mines across Ukraine and in sea lanes has impeded transportation and prevented infrastructure restoration (CSIS, 2022). Moreover, due to the sudden flooding of territory, the infrastructure of the ports and terminals located in the region has been destroyed and disabled, and many ships have sunk and been put out of action.

Arguably, even more disastrous for the navigation of the Dnipro River has been the loss of the Kakhovka reservoir as a result of Russia's terrorist act. The Kakhovka dam connected the ports upstream of the Dnipro River with those of the Black Sea. The water reservoir made river navigation between Zaporizhzhia and Nova Kakhovka possible. The destruction of the dam and the loss of the reservoir made it essentially impossible to navigate parts of the Dnipro River, disconnecting the northern parts of the river from the Black Sea (Reuters, 2023).

Discussions about the need to rebuild the dam or find alternative solutions to restore navigation are active among governmental, private, and public stakeholders. This question is also addressed later in this report in 7. The future of the Kakhovka dam: to rebuild or not to rebuild? So, while the river remains navigable upstream from Zaporizhzhia, the restoration of navigation between Nova Kakhovka and Zaporizhzhia is likely not to be achieved anytime soon, providing financial and safety constraints amid the ongoing war (UIFuture, 2023; Ukrainska Pravda, 2023).

Figure 1. A photo of a tugboat damaged by a russian missile attack
Author: unknown; Source: Nibulon

3.6.3. Implications for industry, agriculture and fishing

As discussed in 2.3. Agriculture and fishing and 2.4. Industry, river navigation in modern-day Ukraine is particularly important for two sectors of the economy: industry and agriculture. Agricultural products and metals are those goods that constitute the core of Ukraine's export capacity, and a large part of them used to be transported by barges along the Dnipro River, mainly to the maritime port of Odesa and other ports of the Black Sea, from where they continued their journey to the most various destinations around the world. A report by CSIS highlighted that seaports are critical for Ukraine as they constitute the main route for exports of metals, chemicals, fertilisers, and, above all, agro-industrial products: more than half of Ukraine's total exports and 90% of grain exports are transported through sea corridors.

Since the beginning of the war, the agricultural sector suffered severe hits, and a part of this was due to the inability to continue using the Dnipro River as a waterway for the transportation of goods. Before the full-scale invasion, the leader in river transportation of agricultural products in Ukraine was Nibulon. The company systematically expanded its fleet and built river terminals on the Dnipro and Southern Bug rivers. Before the full-scale war, Nibulon transported up to 70% of its products via river transport with a fleet of 85 boats, processing up to 4.5 million tons of cargo specifically through river transportation. The full-scale war has blocked operations on inland waterways. In an interview, Nibulon's director of logistics, Serhii Kalkutin, reported that, like other Ukrainian companies, Nibulon faced significant challenges in fulfilling foreign trade contracts, as the ports were immediately blocked. Now, about 90% of the company's logistics are operated by railways, and the remaining 10% are handled by automobiles (Ports UA, 2023). Moreover, as a result of military activities, Nibulon lost three tugboats and five units of non-self-propelled fleet, including barges, which the Russians used to create a crossing under the Antonivskyi Bridge in Kherson.

Since spring 2023, Nibulon was able to renew some activity on the Middle Dnipro River, transporting some 15 thousand tons of agricultural products. However, returning to the pre-war numbers will be challenging. While Kalkutin is more optimistic about the renewal of activities in the port of Mykolaiv, prospects for the Dnipro River in the company are much worse. With the destruction of the Kakhovka lock, there is a common understanding that the restoration of navigation, as well as ensuring safety, will take more time and years. Kalkutin concludes that "if navigation is later opened at least up to the Kakhovka lock, it would already be good". (Ports UA, 2023).

While a major stakeholder, Nibulon is, of course, just one of the many actors that represent the different industries that use the Dnipro River for the transportation of their goods. Ukraine's major private logistics operator on the Dnipro River is Ukrrichflot. Along with other various cargo, Ukrrichflot's main transportation goods before the full-scale war came from both the agricul-

tural and the metallurgical industries, with 0.8 million tons of grain and meal and 1.2 million tons of metal processed by the company ports and facilities annually (Ukrrichflot, 2024). Together, Nibulon and Ukrrcihflot controlled about 75% of the total market of river navigation and transportation. Overall, the company's fleet consisted of about 100 vessels, including those for transportation on the Dnipro and Danube rivers, river-sea vessels, as well as tugs and auxiliary fleets.

In an interview conducted during the course of our own research, deputy CFO Yurii Tereshchenko at *Ukrrichflot* echoed the concerns discussed above. The restrictions on navigation and the destruction of the Kakhovka dam and the Kakhovka reservoir have both put the company in a very difficult situation. In 2022, the company's revenue decreased by almost 3.8 times to 299.79 million UAH. Net loss increased almost 4.8 times to 193.97 million UAH (E Pravda, 2024). With three of its five ports (Dnipro, Zaporizhzhia and Nikopol River ports) now cut out from the Black Sea and the other two (Kherson and Mykolaiv Ports) limited by wartime restrictions on navigation, the company is facing significant challenges. Some of its facilities, like the River port in Nikopol, have been damaged by russian military activities. The challenges that Ukrrichflot is facing are inevitably reflected in those industries that had to find new, often less efficient and more costly, ways of transporting their goods in Ukraine and abroad — either by rail or by automobile. Major stakeholders in the metallurgical sector include Metinvest, ArcelorMittal, DCH, and Interpipe.

Tereshchenko says, "The perspectives in regards to river transportation are not very pleasant". Due to the full-scale war, as the transportation of goods down to the ports of the Black Sea has become impossible, Ukrrichflot has expanded into another industry on the Dnipro River: sand extraction, with over 1 million tons of sand extracted yearly. At the same time, restrictions regarding sand extraction have also been put in place in some areas, complicating work in this industry too (Obuhiv RDA, 2023).

Despite the challenges and limitations, with the many efforts of the Ukrainian government and private actors, but also with the assistance of foreign partners, including the grain corridor initiative, Ukraine was able to remain a key supplier in the global markets of grain and sunflower oil, with a share of over 10% of international trade. For instance, in 2023, Ukraine exported 16.1 million tons of wheat to 65 countries, 26.2 million tons of corn to 80 countries, and 5.7 million tons of sunflower oil to 130 countries worldwide (NISS, 2024).

Nevertheless, Ukraine's total exports remain below one-half of the pre-war level. Ukraine's main export product at the end of 2021 — metals — has shrunk by one quarter from 23% (European Parliament, 2024). Until the end of 2023, the cumulative trade deficit triggered by the russian invasion has approached USD 40 billion, as Ukraine's exports were struck both by damage and occupation of the producing industries but also by the logistics (European Parliament, 2024).

At the same time, another industry was particularly hit as a result of Russian aggression — the fishing industry. Fish stocks have been decimated by the war. Ukraine's State Fishing Agency reported that in 2022, due to the war initiated by russia and the imposition of martial law, around 80% of users of aquatic bioresources stopped or partially halted commercial fishing, with the areas of the Black Sea and Azov Sea basins seeing practically no activity. At the same time, it is emphasised that the catch of aquatic bioresources decreased by over 60% compared to the same period in 2021, which contributes to the challenge of ensuring food security in Ukraine (Agropolit.com).

In the Dnipro River, fishing has been limited and restricted both by martial law and by direct military hostilities, making it impossible to continue the usual commercial activity. While all of the reservoirs have been, to some extent, affected, the worst case could be observed in the Kakhovka Reservoir, where many fish have died after the russian forces destroyed the Nova Kakhovka dam. But the consequences have been felt across the Dnipro Cascade, as the river dropped by about 1.5 meters (five feet) over the winter, reaching a 30-year low — too low to sustain the fish population (NYTimes, 2023)

3.6.4. Implications for recreation

While, understandably, often missed out from wartime commentaries, reports, and discussions, the importance of the recreational aspect of the Dnipro River should not be underestimated. Of course, the war has put leisure to the bench, making tourism or recreation not secondary but virtually irrelevant. It is, of course, a logical response for Ukrainians, whose existence is at stake, making safety and security prime areas of concern. There is also an understanding that, in the long run, wars are won by strong economies, putting a lot of attention on Ukraine's major export goods as the building blocks of economic stability.

But, as mentioned above, life continues, and despite active warfare on the frontline, cities across central and western Ukraine continue their "normal" life amid regular air sirens and airstrikes. When it comes to recreation related to the Dnipro River, many dimensions can be discussed, from the use of public recreational areas to activities on the water to tourism, by and large. We will touch on some of the many areas of attention.

i. Water activities

As discussed above, with the beginning of the full-scale invasion in February 2024, the navigation on the Dnipro River was severely disrupted both by direct military actions — such as north of Kyiv during the early advance, or, for instance, in the Kharkiv region where both banks of the Dnipro River were under occupation — and by restrictions put in place by Ukrainian authorities as safety measures. When it comes to regulations related to martial law, restrictions included the navigation of "small, motorised, recreational, sports, and high-speed vessels, as well as water motorcycles and recreational equipment".

Some exceptions do occur. For instance, in July of 2023, a competition by the Ukrainian Sailing Cup was organised and hosted by the "Sich" Yacht Club on the Dnipro River in the city of Dnipro. The tournament gathered nearly three dozen athletes. Despite the prohibition of martial law, an exception was made for athletes to recover competitive practice (DP Informator, 2023). However, the general picture remains unchanged, with significant restrictions on the use of the Dnipro River waters.

ii. Fishing

Unlike in other water bodies, such as ponds, lakes and small rivers, recreational (sport) and commercial fishing and the harvesting of aquatic bioresources were also prohibited across major areas, including, among others, the Kakhovka and Dnipro Reservoirs. Restrictions on recreational fishing are a usual and seasonal thing; however, with the war in Ukraine and the losses in the fish population, this issue has become much more pronounced.

As the head of Ukraine's State Water Agency, Ihor Klymenok has commented: "Today, in the context of war, when Russian occupiers are already destroying our fish populations everywhere, it is very important to give the fish the opportunity to spawn peacefully. Therefore, I urge everyone to treat spawning fish responsibly and adhere to the established restrictions" (DARG, 2024). The ban applies to both recreational anglers and those engaged in commercial fishing and extends to underwater hunting enthusiasts.

iii. Tourism

Despite the war in Ukraine, some tourists continue to visit the country. However, the recreational uses of the Dnipro River are unlikely to be the main motivation for their journeys. When it comes to the local populations, internal tourism has been developing in Ukraine, boosted by the COVID-19 pandemic that brought significant restrictions on international travel, and the ongoing war undoubtedly contributes to some internal movements.

But many areas of the Dnipro River, including the Chornobyl area, which used to be a main tourist attraction, but also the Dnipro Delta remain closed for tourism due to the ongoing military hostilities and the proximity to enemy frontlines. The implications for the Dnipro River have been clear. Much like for the majority of war-affected regions in Ukraine, the Dnipro River has become a less safe place not only for doing business but also for recreation, tourism, and leisure. The conflict has significantly impacted the river's role in everyday life, diminishing its recreational and economic potential and highlighting the broader consequences of war on natural resources and public spaces.

3.7. Culture under attack

3.7.1. The lost heritage of the Dnipro River throughout history

As described in the previous chapters, the Dnipro River is a powerful symbol of Ukrainian culture, identity and history. Throughout the centuries, many civilisations have settled along its banks, founded villages, towns and cities, and crossed it again and again, from North to South and from East to West. The long history of interaction with the Dnipro River makes it particularly important, not only in a material and physical way but also in a more abstract, ideational and symbolic way. The Dnipro River is, in a sense, a symbolic line that ties all those things from history together. Today, as in the past, the Dnipro River means a lot and many more things to many people. The Dnipro River is a source of life for Ukrainians, but it is also for Ukraine as a country and as a nation. From basic water needs to the development of the economy, industries, energy, agriculture, trade, fishing, navigation, recreation, tourism and many others, the Dnipro River presents itself as deeply engrained into the everyday lives of many Ukrainians. It has been for a very long time, as history reveals.

But what history also reveals is that often, the river is “caught in the fire”, becoming both a weapon and a target at the same time. The savage toll of past wars is visible everywhere. The burial mounds of Scythian fighters killed thousands of years ago can be found near memorials to soldiers and civilians killed in World War II, but also, among others, on the famous Khortytsia Island — home to the Cossacks some centuries ago. The Dnipro River is well known for the famous Battle for the Dnipro (1943) during the Second World War. But wars aren’t the only traces of the Dnipro River that have been found. Its significance for Ukrainian culture is seen through the literature, poems, paintings, films, architecture, traditions, and many other forms of self-expression. These cultural representations of the Dnipro River, associating Ukrainian identity with the river, also made it more vulnerable. For decades, the distinctiveness of Ukrainian culture, language, symbols, traditions, religion, and identity was repressed, and the Dnipro River sometimes paid the price, too, as a source of national strength and pride, not least, a source of inspiration.

Since the imperial times, occupying russian rulers used the Dnipro River, among others, to crush the spirit of Ukrainian resistance that has long been nurtured, not least among the Cossacks. The Cossacks were repressed by the russian empire, and along with them were destroyed the physical heritage they had left. The famous Cossack Siches of the Great Meadow along the Dnipro River were all destroyed. In the Soviet times, the remains of those Siches were flooded, together with the many villages, churches, cemeteries, and archaeological sites of different ages that were located in the valleys of the Dnipro River. In the Kyiv reservoir alone, more than 300 settlements of the Ancient Rus era went underwater, including settlements mentioned in the XI century, such as Starosillya, where Volodymyr Vernadsky later famously set up the summer laboratory of the biological station of the Ukrainian Academy of Sciences in 1918 (UNCG, 2022). Along with the cultural landmarks, hundreds of villages were also flooded, destroying a whole array of immaterial culture transferred from generation to generation. Some of these have retained a place in our memories, in photos, films or in the books, while others have been lost forever. The Dnipro River was again reinvented and reshaped to suit a different narrative.

3.7.2. Russia’s attacks on material and immaterial culture today

In modern times, the Dnipro River, too, witnesses history and, in fact, takes an active part in it. Graveyards across Ukraine have continued to grow since 2014, as russia started its war in the Ukrainian Donbas, and more so since the beginning of Russia’s full-scale invasion in 2022, as hundreds and thousands of killed Ukrainian soldiers are buried. Russia’s war has brought unprecedented damage to Ukraine, with whole cities like Bakhmut or Vovchansk razed to the ground. As discussed in the first section of this chapter, 3.1. The Dnipro River as a frontline, the river and its water have continuously been weaponised, playing a major role as a natural frontline between russian invaders and Ukrainian defenders.

While targeting civilian populations, raping, torturing and murdering innocent men, women and children, Russian forces also deliberately strike at Ukraine’s many cultural sites. The Ministry of Culture and Information Policy of Ukraine continues to document damage to cultural heritage sites in Ukraine as a result of Russian aggression. From February 24, 2022, to March 25, 2024, Russia has destroyed or damaged 1,046 cultural heritage sites throughout 17 regions. Of these, 128 are of national significance, 848 are of local significance, and 70 are newly discovered (MKIP, 2024). These include museums, churches, libraries, schools, theatres, parks, architectural landmarks and many other elements of cultural heritage. Excluding cultural heritage sites, another 1,974 cultural institutions have been damaged (including those under the Ministry of Culture and Information Policy and other central executive authorities) by Russia as of March 25, 2024, of which 321 (16.3%) have been destroyed completely.

Today, as Russia is waging its brutal terrorist war against Ukraine, the Dnipro River, too, again becomes implicated, threatened, attacked, and weaponised, resulting in Ukraine’s economy being disrupted, infrastructure vandalised and destroyed, nature brutalised, contaminated and brought to death, people left to flee in search of safety — if not from the occupying russian military forces, then from the massive floods that they caused with their bombs. As an article by Ukrainska Pravda phrased it, while the russian occupiers have been waging war against Ukrainians for over ten years, they have also been “waging war against the environment” and “denazifying waterbodies with their mines”, with Ukraine’s main artery — the Dnipro River — and its ecosystems bearing the consequences (Ukrainska Pravda, 2022). As hostilities continue, it has become evident that Russia is waging a war not merely against Ukrainian soldiers or political leadership but a war aimed at erasing Ukraine as a nation and as a culture — a genocide, truly.

Eventually, events like the destruction of the Kakhovka dam go far beyond their local or regional scope, impacting hundreds of thousands of Ukrainians physically, as many find themselves without home, water and/or electricity. But beyond that, such attacks on the Dnipro River became, for all Ukrainians, yet another defining event entrenched into the collective memory and identity associated with the Ukrainian War of Resistance against Russian aggression. The damages caused to or by the Dnipro River elevate it and give it a more profound symbolic meaning.

3.7.3. Conclusions

The magnitude of the Kakhovka dam destruction will undoubtedly be remembered for decades and centuries to come, just like the destruction of the DniproHES in the 1940s is today. But many other, smaller, more personal stories will also be remembered by those people who suffered from the war.

A fishing enthusiast will remember not being able to go fish, as he used to do all his life. A young kid dreaming of being a professional sailing competitor will remember not being able to practice, unlike his peers from other countries. A young mother will remember not being able to take her child to the waterfront, as her mother has done in her childhood. An old couple will remember losing their home due to the flood.

These stories are all hypothetical, and yet they are certainly very true. No Ukrainian has probably not felt something changing in their life due to the war. Those interacting with the Dnipro River — either by riding a boat, swimming, crossing it on one of the bridges, or simply seeing it every day — undoubtedly noticed the changes that occurred with the river. And for them, the scars of the river are also personal scars, which collectively leave a scar on national Ukrainian culture.

How can we deal with those scars? How can we protect the Dnipro River for ourselves but also for the sake of a healthy natural environment and a planet Earth preserved for the next generations?

These are some of the questions we asked ourselves during our research. The next chapters of this report attempt to provide some answers. Some are more abstract, others more concrete. Finding the right answers is always a challenge, a balancing act, weighing the interests of the many stakeholders related to the Dnipro River.

The large scale of the river makes this task even harder. To make the right decisions, we are persuaded that one should, above all, be well informed about the context because a prosperous and healthy future for the Dnipro River and for the people of Ukraine can only be done with strategies that take the national, regional and local contexts into account, both that of the present and that of the past.

The chapters above are our attempt, to the extent that time and resources allowed us, to better understand this context. Of course, many elements will still be missing. Everyone reading this report will probably think of something they would have included in one section or another. If you did, then we did our job well because, after all, one of the goals of this book is to trigger more discussions about the Dnipro River and about the ways we want to see it develop in the future.

We hope that the Chapters behind gave you a good and clear picture of what the Dnipro River is, where it is situated, how our human interaction with the river developed throughout centuries and millennia, what the Dnipro River means for us today, how essential it is and why, but also what are the various challenges that we faced in the past and, most importantly, today, as Ukrainians are resiliently fighting for a free and independent Ukraine of the future.

Part 4
Strategies and visions for the future of the Dnipro River

Contents

Introduction

As described in the previous chapters, the Dnipro River has many different meanings and values – simultaneously and sometimes contradicting. It is a central element for Ukrainian economic activity, be it industry, agriculture, transportation or other, a core element in household water supply and sanitation, an important tourist attraction, a place for recreation with its rich biodiversity and ecosystems, and last but not least, a core symbol for Ukrainian culture and statehood, which inspires and unites people. The Dnipro River is everything enumerated above and much much more.

But, eventually, looking at the history and at the present of our human interaction with the river, we can see that much too often, despite the eloquent, poetic tributes and admirations, the Dnipro River is looked at as merely a resource. A plentiful resource that is there to meet many of our human needs. People need water to drink, people need water for personal hygiene, and people need water for economic activities. But, more worryingly, we also see water weaponised during wartime turned into a weapon of mass destruction, as masses of water destroy everything on their way, flooding hectares of land. While trying to explicate the motivations behind the actions committed in Ukraine by the terrorist russian state — a state accustomed to murder and genocide — is out of the scope of this report, the day-to-day interaction of Ukrainians with the Dnipro River — is.

In that regard, while water is, of course, a vital resource, seeing the Dnipro River as merely a resource reinforces the notions that the river and the environment at large are 'a separate thing' and that human beings are detached from or superior to the 'natural world' (Shellenberger and Nordhaus, 2005). This abstraction of 'the human' from 'the environment' has been widely discussed among academics. On the one side, anthropocentrism considers humans to be the most important among all life forms, while non-human species and processes are only deemed vital to the extent that they are beneficial to or affect humans in some way (Satterfield 2002, p. 153).

At the same time, diametrically opposed ecocentric and biocentric world views have, somewhat ironically, also emphasized the disconnection of 'the environment' from the 'environment-around-us', where wilderness is seen as an entity to be preserved from humans, framing us as both pollutant and polluter in these places (Devall and Sessions 1985, Naess 1989, Foreman 1991, Fox 1995). As Castree (2001) points out, where anthropocentrism proposes to manage, control, and dominate nature, eco-centrics urge to save it, live in harmony with it, or even get back to nature (pp.4-5).

So, although diametrically opposed in their approach to humans and the environment, both anthropocentrism and ecocentrism have the same effect: they disconnect the environment from our everyday lives (Anderson, 2010, p.977). Framing the environment as something alien or separate from everyday spaces of human life (Burningham and Thrush 2001) "has the effect of abstracting us and our activities from the environmental consequences they may have." (Anderson, 2010, p.977). "This intellectual process of abstraction is compounded by […] the industrial culture of (over) consumption and development in which Western society is saturated" (Idem). The same can arguably be said about the Dnipro River. For centuries, it has been seen by humans as a resource from which water can be extracted in quantities that are necessary, while discharges of polluted waters remain undealt from year to year. Soviet interference and disruption of ecosystems via the erection of dams and reservoirs have been followed by a period of negligence during independent Ukraine, as industries, agriculture, and cities continued (and continue to do so today) to pollute the Dnipro River.

We believe that this approach is simply not sustainable anymore. We have reached a point where the consequences of our actions have significant implications not only in the long term but in the immediate future. We cannot afford to simply continue taking from nature without giving back. The least we should be thinking of

Figure 1. Drone footage of the Dnipro River along the dam of the Kyiv Reservoir.
Author: © Antoine Korchagin

are ways to minimise the harm that our human activities cause. Of course, sometimes, things are out of our control. On the one hand, climate change is irreversible, and we are left to adapt to the new realities. That being said, it does not mean we can't do anything to slow it down and reduce the potential harm, but some changes are predictable and imminent. On the other hand, we are faced with the harsh realities of war, human savagery, inhumanity, and ruthlessness.

The russian war against Ukraine since 2014, and especially its full-scale invasion since February 2022, has led to devastating consequences in all possible aspects of our lives, from basic human survival, our built environment, and the nature that surrounds us, to our social and economic wellbeing and others. Other things, however, are more tangible and have a direct relation to how we act at both the individual and the macro-state levels. While we keep polluting water and ruining ecosystems, we cannot expect to sustain an environment that allows our generation and the next ones to have a clean and abundant water supply to provide for the growing needs and demands of our societies and economies.

We do not argue for an ecocentric view, understanding that human existence is bound to come into conflict with the environment in one way or another. However, we recognise that there needs to be more consideration of our role and place in the natural ecosystem, a deeper connection with the river and an understanding of the consequences of our actions with respect to the natural habitats, but also, more practically, how these changes might backfire at us. The Dnipro River is inevitably a resource for human activities. We cannot ignore that. However, we should also be able to view the wider picture and understand that the way we interact with the river defines our social, economic, and, therefore, political well-being.

An alternative approach?

This report tries to define a better balance between the so-called technological needs of the human population and the nature.

The questions we ask ourselves are: How can we rebalance our increasing technical needs for water supply and the river's essential role in the natural ecosystems? How can we improve or keep supporting a good quality of life in our communities, whilst simultaneously ensuring and safeguarding the river's long-term health and ecological integrity? In what ways can we ensure that our utilisation of the Dnipro River meets the diverse needs of society, including agriculture, industry, and domestic use, without compromising its sustainability for future generations? What water management practices and solutions should be proposed? What policies and regulations should be cosidered? How to adapt to the ongoing realities of war and provide more resilient approaches? What are the main stakeholders and who should be involved? More broadly, what are the guiding principles that define the priorities in our interaction with the Dnipro River?

The present report is not a River Basin Plan as such, but the ideas and perspectives presented in the previous sections and the ones that follow, we believe, can be instrumental in contributing to a more comprehensive and integrated River Basin Management Plan, that will respond to the various themes and topics discussed here with even more precision and hopefully provide a concrete plan for international development aid monies to support their implementation. We start with water.

Because, above all else, the Dnipro River, like any other river, is water. We then continue by suggesting our visions and perspectives for the different 'layers' discussed in the previous chapters, that depend and rely on Dnipro River and its water: ecology and biodiversity, energy, industry, agriculture, fishing, transportation, tourism, recreation, security and safety but also culture and heritage.

By considering and connecting these different the layers, we aim to identify the unused potential of the Dnipro River and suggest some of the possible alternative strategies of approaching and interacting the river that we believe would allow to bring its full potential to life. In our proposals we try to inform and inspire, provide relevant examples and references, acknowledge the possible limitations.

This chapter looks at the larger context, which aims to cover the Dnipro River and its basin as a whole, with all the limitations that come with this very general and sometimes too broad approach. With the aim to illustrate the visions discussed in the chapter below in more detail and provide more concrete commentaries and views, our later Chapter 6 will reflect on what is discussed here by zooming into a specific case study — Kremenchuk city.

Interviewing
Elyzaveta Pererva

22 years old
Born in Kyiv
Lives in Kremenchuk

I work in technical support, but my main passion is cultural activities. Last year, my friends and I created a music studio. I'm also a trained filmmaker, though I rarely shoot films now.

I first visited the Dnipro River when I was four. We lived a few metro stations away from the river in Kyiv, and during the summer, my parents and I would go swimming there. My first memory of the Dnipro is standing by the river, looking at the South Bridge. The river seemed brown and green, like tea, and I told my parents that the Dnipro was a river made of tea.

For a long time, whenever I thought about the Dnipro, I pictured the place from my childhood near the Slavutych station by the Southern Bridge in Kyiv. The smell there was awful, like something was rotting, and the noise from the subway trains added to the typically sad and discouraging mood, which perhaps reflects childhood in general. Now, when I think of the Dnipro, I see the crowded riverbanks in Kremenchuk. Once, in a terrible mood, my friend and I went for a walk to clear our heads and ended up on the riverbank by the Dnipro. It was dusk, and in the distance, I thought I saw flamingos skimming across the water. I know there are no flamingos in Kremenchuk, but they were some birds with long legs, running along the water's surface. It felt amazing, like a promise of relief, and it pulled me out of that terrible state I was in. It felt like a miracle. Ever since then, I see the Dnipro as a place where you can experience life anew and feel that everything will turn out okay in the end.

I usually come to the river to look at it and listen to it. I haven't swum in the Dnipro since I was a child, though I may touch the water with my hands or wade in up to my knees. I see the river more as a place for meditation and self-soothing.

I wish the river looked clean. Often, there are unpleasant, suspicious smells on the Dnipro that don't seem natural. For example, the Psel River smells like clay or earth, or maybe a little like flowering plants, but the Dnipro often smells like dead fish or something similar. I wish there were no disturbing odors. I also wish there were no fishermen because, like hunting, fishing seems immoral to me in modern times. I'm also concerned about ships on the river. If their engines are running, they produce emissions—do these evaporate or go into the river? I'd like to see these ships use alternative fuels that don't pollute the river.

To me, an ideal river is one with minimal human intervention, without innovations aimed at exploiting the river rather than preserving its well-being. The river and nature know how to exist and be perfect on their own.

The most challenging aspect is negotiating. Currently, it's more about corporations and the government. The government supports corporations because they pay taxes, and corporations exploit rivers. I don't know how to resist this capitalist machine that is ruthless to rivers and nature, even in the face of environmental disasters. Therefore, negotiating with factories to prevent waste dumping, and convincing people not to pollute the river, is very difficult. But the hardest part is communicating the need for habit changes to make the river more prosperous.

I believe that if people have positive experiences interacting with nature and see how it benefits their health and lives, there will be less negative impact on the river.

4.1. One water. Clean water. Abundant water.

Introduction: Context

We want to start with water, because, above all else, the Dnipro River, like any other river, is about water. Chapter 2 has shown that the water of the Dnipro River are fundamental for probably all aspects of life in Ukraine. It provides primarily for our basic sanitation and hygiene needs, it is used in agriculture and in industrial activity, it is used in energy generation, be it hydroelectric power or other sources of energy, it plays a significant role in tourism and recreation with its many locations. At the same time the Dnipro River continues to be not only a resource but also a habitat for many species, including fish, birds, mammals, inspects, plants and others.

Nevertheless, while so many things around us are so dependent on the Dnipro River, water, or inversely the lack of therein, can often constitute a significant challenge too. Water is weaponised, water is polluted, water is wasted, leading to further insecurities in health and safety, impacting both the human populations and the natural environment. In summarising all those challenges we can identify two main problems: one has to do with water quality (that is — pollution) and the second with water quantity (read water scarcity). These major issues are redundant throughout our research and we believe require specific attention in this section. In turn, both water pollution and water scarcity link back to the discussion introduced in the introduction to this Chapter. Namely, that our often anthropocentric approach to viewing water further deteriorates the above mentioned problems linked to the quantity and quality of freshwater. The research illustrates that russia's armed aggression has led to colossal social, economic and environmental damages, including to water-related infrastructure, the impact of which should not be diminished. However, problems related to water scarcity and water pollution existed even before the war, related to more systemic flaws.

Our visions and strategies

We recognise that any visions and strategies proposed today in response to the challenges mentioned above inevitably require a multidimensional approach that takes both pre-war and wartime challenges into account. When it comes to the risks and threats associated with military actions, some ideas are discussed in more detail in section *4.9. Safety and Security.* The current section, instead, while considering the importance of developing a more resilient and secure water system, focus on the more fundamental approaches related to water resource management. In that regard, we want to stress that, above all, water should be seen as 'one' — that is, indivisible (*See 4.1.1.*). Only then, we believe, can we truly start thinking of strategies to make this fundamental resource sufficient (*4.1.3.*) and clean (*4.1.2.*). In essence, our core view is that water must be managed sustainably in order to equitably meet our essential needs, while also doing so with respect to the natural environment of which we are fundamentally a part of.

"Like all living organisms we are composed of water. Therefore, water is the foundation of our life. The Dnipro River is, of course, not directly, but a source of our drinking water. That is, all bodies of water, even small lakes, small rivers – each of them needs to be protected, prevented from pollution and disappearance"

– Ihor Abram'yuk,
Institute of Hydrobiology of Ukraine
(from an interview to Ukrainer, 2021)

4.1.1. The One Water Approach

We have seen in the previous chapters that water is both a resource that humans use for their various needs, but at the same time it is also a habitat in itself, a home to many species that also live off it. Understanding this dynamic, we believe, is the essential task in approaching how we use and manage water resources in general in the Dnipro River and its basin.

Historically, land-use planners have not extensively engaged in water resource management, relying on water utilities and engineers. However, growing challenges like population growth, pollution, and climate change necessitate a paradigm shift toward more integrated management. This One Water principle is perhaps best developed in the report “Planning for River Basins and Water Resources” by William Cesanek, Vicki Elmer and Jennifer Graeff from the American Planning Association (APA), presented in the Environmental Sustainability Planning Guidelines for Building Back Better in Ukraine (PAS Report 588).

One Water views all water within a watershed as interconnected, advocating an integrated approach to managing water supply, wastewater, and stormwater. This paradigm aims to replace industrial-era, siloed systems with sustainable, interconnected strategies. Benefits include improved resource sustainability, conservation of ecosystems, and flood avoidance. The interconnectedness of water systems is central to this approach, emphasising integrated management to prevent problems in one domain from affecting others. Planners, and other water professionals, with their collaboration skills and regulatory understanding, play crucial roles in coordinating water resource management. However, the involvement of a multiplicity of stakeholders that define and shape how water is managed is also necessary to ensure a truly integrated approach. These may include planners, engineers, landscape architects, scientists, legal professionals, economists, but also all the various users from the different sectors.

The One Water approach is based upon the understand of the basics of the water cycle and includes three infrastructure systems: water supply, wastewater, and stormwater (see Table 1).

The integration of water management into urban planning through the One Water approach is imperative. Planners and other water professionals must understand water basics, collaborate with water professionals, and adopt sustainable practices. This paradigm shift is crucial for addressing contemporary challenges and ensuring a resilient and interconnected approach to water resource management in urban environments.

Table 1. One Water Approach: Three infrastructure systems

1.	*Water supply* – drawn from surface and groundwater sources, is crucial for human use. Per capita water use trends guide planners in creating sustainable practices to meet future demands.
2.	*Wastewater* – a byproduct of various water uses, undergoes centralized or decentralized treatment to prevent pollution. Increasingly, wastewater is viewed as a resource for recovery and reuse.
3.	*Stormwater* – precipitation runoff in urbanized areas, historically addressed by fast conveyance piping to alleviate flooding (“gray infrastructure”), is now reconsidered with green stormwater infrastructure and low-impact development designs to protect the natural environment and ecosystems.

Figure 2. Water infrastructure in the Dnipro River near the Kaniv HES,
Source: Oleksandr Malyon

The One Water Approach and transboudary rivers

At the same time, the principles of the One Water Approach are also very relevant to the topic of transboundary rivers. As discussed in Chapter 1, international and national borders pose a significant challenge to rivers and the Dnipro River is not an exception. Frontiers disregard the natural ecosystems, as well as the sustainable use of water resources across borders.

The One Water Approach contributes to a more integrated water resource management that is built on the cooperation of different stakeholders, a model to be considered by governments in their transboundary river management.

Of course, as discussed earlier, a cooperation between Russia, Belarus and Ukraine is rather unrealistic, given the current political realities and the war that Russia is waging against Ukraine. However, we would like to nonetheless highlight some of the principles described by UN Water (see Table 2).

Overall, understanding and accepting the One Water Approach is a foundational step that shapes the way we deal with the two further issues: the pollution of water on the one hand and the scarcity of water on the other hand.

However, it should be noted that the application of the One Water Approach principle in the conditions of the Dnipro River basin is complicated by several factors.

First and foremost, the historical development of a cascade of dams and embankments effectively severs direct connectivity along the river, dividing it into distinct sections - reservoirs. Additionally, there is an existing practice of prioritising the needs of industry and agriculture, as well as an inefficient urban water supply system.

To change the current situation and implement the One Water Approach principle, it is necessary to change the philosophy of interacting with the river and utilising its resources.

This involves reevaluating approaches to existing water infrastructure projects, minimising losses during transportation, and effectively treating and reusing purified water.

Furthermore, for the full implementation of the One Water Approach principle, it requires intergovernmental transparent partnerships among the countries through which the Dnipro River flows - namely Ukraine, the Republic of Belarus, and the Russian Federation. However, it is evident that such cooperation is impossible under the current conditions of military aggression against Ukraine. Such collaboration should be based on principles of full equal partnership and professionalism, as well as minimising any political or military influence.

Table 2. UN Principles regarding transboudary water management

1.	*Governments must cooperate on transboundary water resources management*. More cooperation is essential, especially in areas vulnerable to the impacts of climate change and where water is already scarce. Transboundary basins and aquifers create a nexus of hydrological, economic and social links between communities living in border areas, and beyond.
2.	*Transboundary ecosystem services must be protected*. Wetlands around lakes and floodplains that straddle national boundaries provide essential ecosystem services to the surrounding populations, such as food provision, barriers against flooding and the natural processing of pollution.
3.	*Economic integration across borders is vital*. Heavily water-dependent sectors – agriculture, industry, energy and water supply and sanitation – need to cooperate on a supranational level. For example, efficient, cooperative management and development of shared waters and adjacent flood plains can boost food and energy production, helping to reduce poverty and control rural-urban migration.
4.	*A 'source-to-sea' approach in transboundary water cooperation must be strengthened.* Parties to the United Nations Economic Commission for Europe (UNECE) Water Convention, a legal framework for transboundary water cooperation worldwide, must develop and protect the linkages between terrestrial, freshwater and marine environments.
5.	*Data gaps must be addressed.* Governments in many countries urgently need to improve their systems for monitoring transboundary waters, especially groundwater, and sharing information with other governments as part of cooperation arrangements.

Interviewing **Oleh Lystopad**

Journalist, biologist, correspondent of the "*Svit*" newspaper

I spent the first year after the full-scale invasion in the Armed Forces of Ukraine. Then, due to my age, I was cast aside like yesterday's newspaper and returned to my civilian profession as a journalist writing about environmental issues, collaborating with many organizations.

When discussing the Dnipro River, we should really consider the entire basin.

If we block the tributaries, the main channel will soon run dry. Our territory is a tilted plane, with everything flowing towards the Baltic, Black, and Azov Seas. Without rain and snow, we'll be left in a desert. People often don't think about the water's source, even though 70% of Ukraine's population drinks from the Dnipro. We must learn to think about climate and water protection.

Sadly, those entrusted with managing these resources are doing a poor job. In 2020, low water availability due to little rain and snow led to restrictions on the Dnipro's water use. The Water Code prioritizes restrictions for energy, industry, and irrigation, with domestic conservation last. The Dnipro's water levels depend on tributaries like the Desna and Prypiat.

Officials believe reservoirs can solve all problems by storing and releasing water, but this didn't save us in 2020.

Another issue arises when there's too much water, causing flooding like in 2023. To solve this, we must preserve marshes, which act as giant sponges. Peat can hold ten times its weight in water, absorbing it when abundant and releasing it when scarce. However, peatlands are being sold, extracted, and processed, destroying this natural sponge.

To save the Dnipro, we need a moratorium on peat and amber mining in Polissia. Destroying peat bogs for short-term gain will cost society in the long run.

In the past, reclamation destroyed many swamps by diverting water and drying them out. The real value of peatlands is uncounted. We need a moratorium and experts to assess and protect them.

River floodplains face similar issues with sand extraction. Despite talks of green reconstruction post-war, river sand deposits have already been sold. Extraction lowers water levels and decreases availability, as rivers flow not only above the bed but also through the sand, slowing the flow into the Black and Azov Seas.

We proposed banning river sand extraction, but it was deemed too radical. They claim we need it to rebuild the country, but alternatives like dry deposits and quarries exist.

Judicial reform is also crucial. Statistics show that out of every thousand reports, only one reaches the court, gets decided, and is enforced. We must address legislative loopholes and lobby for change, which is difficult, especially post-invasion. Implementing legislation, like environmental control laws, is problematic. Inspectors can't enter polluting companies, as fines for obstruction are much lower than for violations. More inspectors are needed to cope with the added burden of recording war damage.

I didn't come to the Dnipro; it came to me during university internships in the Kaniv Nature Reserve. As a student, I learned that anything left on the bank could float away during water discharges from power plants.

Now, I enjoy relaxing at Hydropark or Trukhaniv Island, especially along the rowing canal banks. A simple picnic and a book make for a wonderful half-day getaway when I'm tired from socializing.

Growing up in Vilniansk, Zaporizhzhia Oblast, my father was an avid fisherman who made an aquarium. The beautiful, shimmering rhodeus fish, though not commercial, can sometimes be caught. Living in Kyiv's Teremky-2, I'm still connected to the Dnipro basin through the three lakes and Nyvka River that flow into it.

4.1.2. Water quality: Clean water

When it comes to the quality of water, the One Water Approach and its consideration for the natural cycle of water emphasises the idea that securing a steady supply of clean water for the needs of the population is impossible, whilst rivers continue to be polluted. Introducing clear adaptation and mitigation measures to face the problem of water pollution is imperative. As defined in the joint Plan of Actions by Ukraine's Water Agency and the EU4Environment, this means both the reduction of pollution by organic, biogenic and hazardous substances and the improvement of the hydrological regime and morphological indicators of the river (EU4Environment, UNECE, 2023). Achieving those is not an easy task and requires a detailed and comprehensive approach.

Each water body is a clear representation of the attitude that people have towards it. Every action we take will have consequences and it is only by respecting our rivers that we can have a harmonious, healthy and efficient society

– Olena Bilous, Senior Research Fellow at the Institue of Hydrobiology of the National Academy of Sciences of Ukraine

The Dnipro River Basin Management Plan Draft (December 2023)

In December 2023, the draft of the Dnipro River Basin Management Plan for Ukraine 2025-2030 was published for public feedback. The State Agency of Water Resources of Ukraine and the Ministry of Environmental Protection and Natural Resources of Ukraine facilitated a process of several public information sessions including open feedback forms.

Over the past few years, Ukraine and the five other Eastern Partnership countries have demonstrated their willingness to align their water sector policies and practices with the European Union (EU) and other international Multilateral Environmental Agreements (MEAs). Moreover, as part of its commitments under the Association Agreement (AA) signed with the European Union, Ukraine is aligning its national water policies and strategies with the EU Water Framework Directive (WFD).

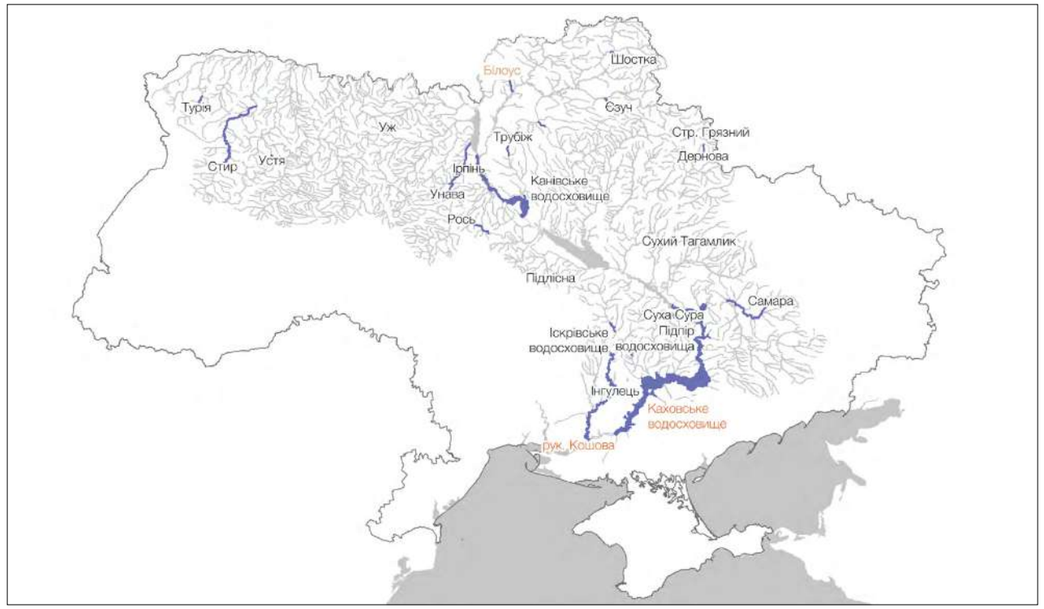
This document, the "Draft Dnipro River Basin Management Plan for Ukraine, Part 1" has been developed in the framework of the European Union-funded programme "European Union Water Initiative Plus" (2016-2021).

This is the first draft River Basin Management Plan (RBMP) for this river basin district. This draft RBMP contributes to the implementation of basin principles and integrated water resources management approaches in the country. However, it does not claim to meet all requirements of the EU WFD. This report contains the first chapters of the Dnipro River Basin Management Plan in Ukraine for the 6-year period 2025-2030. The final and complete draft must be submitted to the Cabinet of Ministers of Ukraine no later than 1 August 2024. Several conclusions can be identified from the Draft Dnipro River Basin Management Plan (see Table 3).

Figure 3: Photo of a member of the Institute of Hydrobiology of the National Academy of Sciences of Ukraine during a research expedition to the Kaniv reservoir in 2019. Source: Ukraïner.

Table 3: Conclusions from the Dnipro River Basin Management Plan Draft (December 2023)

• The biggest share of its water is used by the manufacturing industry (43% of the water used in the river basin).
• In the Dnipro River Basin District, 20 river types, five lake types and two types of transitional waters have been identified. Within the five sub-basins of Dnipro River Basin District (Upper Dnipro, Middle Dnipro, Lower Dnipro, Pripyat and Desna), 3,879 Surface Water Bodies have been delineated and 26 groundwater bodies and groups of groundwater bodies have been identified and delineated.
• More than 50% of the surface water bodies are likely to achieve a good status at the end of the planning cycle. Among the others, around 25% are at risk of not reaching a good status at the end of the planning cycle, and the remaining are considered potentially at risk. The main causes are: excess crop fertilisers, discontinuity of river beds and damage of morphology. However, more than 80% of the groundwater bodies are likely to achieve a good status at the end of the planning cycle. The main pressure is agriculture, with nutrients leaching down into the groundwater.
• The cost of water services is not fully recovered, with large gaps between users.



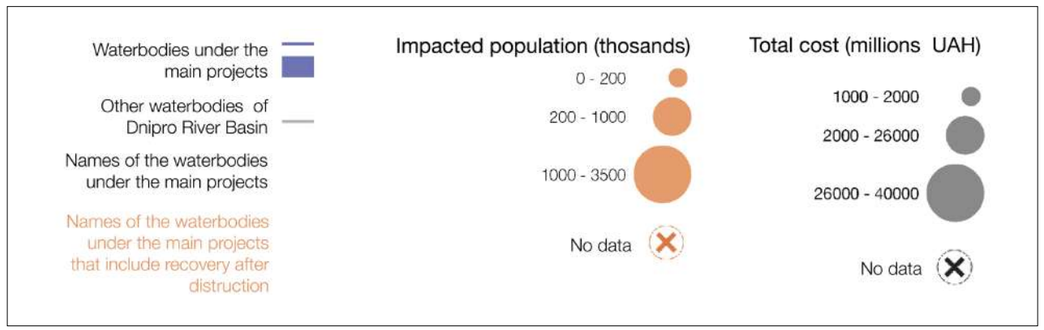


Figure 4: Map of the main projects from the Dnipro River Basin Management Plan
Author: Elaborated by Ro3kvit and Greenpeace CEE; Data from DRBMP (2023).

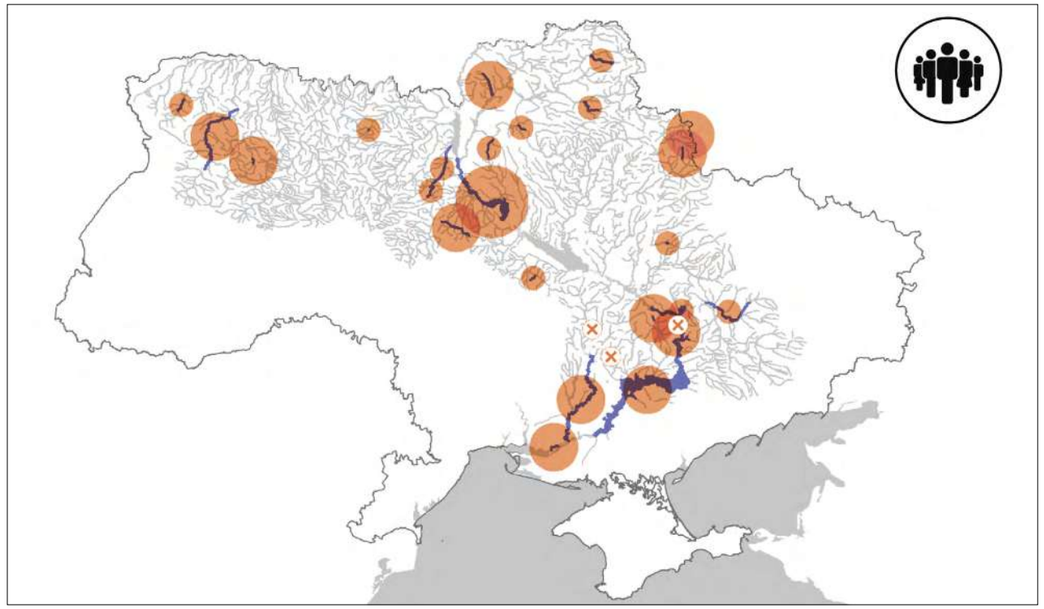


Figure 5: Infographic map visualising the total cost for each project
Author: Elaborated by Ro3kvit and Greenpeace CEE

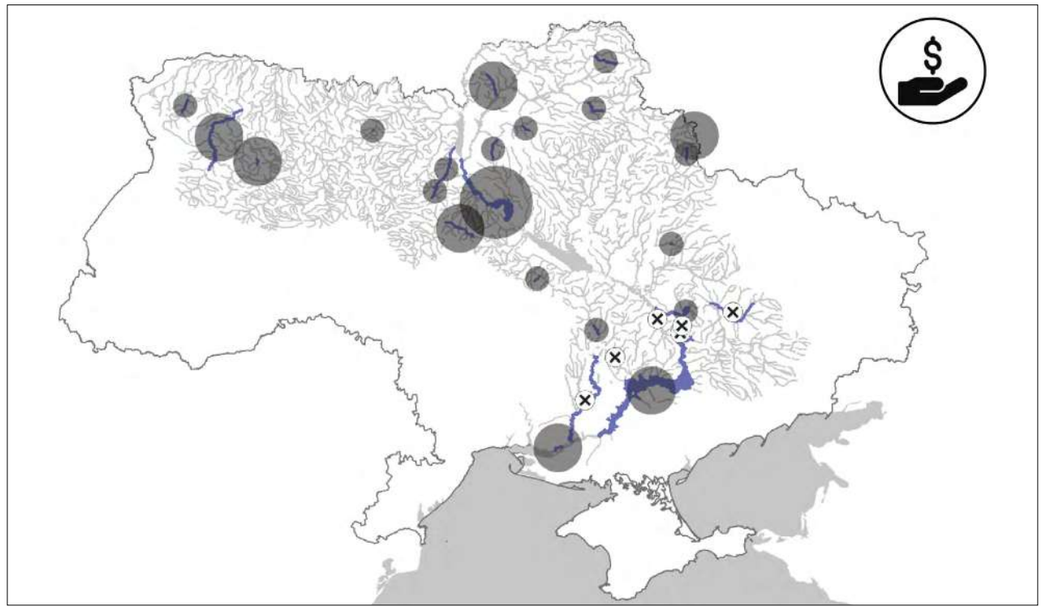


Figure 6: Infographic map visualising the population impacted by the projects
Author: Elaborated by Ro3kvit and Greenpeace CEE

4.2. Protected nature and biodiversity

Introduction

While there is a lot of potential for improvement, the first step to be taken before anything else is to stop additional harm being done to the natural environment. Ukraine's ecologically important areas continue to be heavily impacted by the conflict, and in some areas, the loss of species or habitats will be permanent. The true extent of ecological harm remains unclear, even if the impact of the conflict on Ukraine's capacity for biodiversity protection is becoming more apparent. As with climate change adaptation and mitigation, recovery from the conflict presents opportunities to enact policies that encourage a greener future. Nature recovery should be viewed as a priority because of the benefits it can bring to Ukraine's society and economy, as well as to its biodiversity (CEOBS, 2024). Below, we propose a series of actions we believe should be understood and taken into account by all stakeholders.

Figure 1: Photo of the Dnipro River near Trakhtemyriv (Kyiv region).
Author: Dovkola Media

4.2.1. Measuring biodiversity

Based on the analysis in 2.1. Natural environment and biodiversity, we can conclude that within the Dnipro River basin, there was incredibly rich biodiversity before the start of the invasion. There are records of 8 114 unique animals and 3562 unique plant species within the Dnipro River basin, including 524 protected and rare animals and 589 unique protected and rare plant species. Almost all analysed datasets are from 2021, 2022 and 2023, which means that the data is quite actual, but because of the war situation, it changed drastically. Measuring biodiversity can be an extremely challenging process that requires a lot of effort to reach reliable and confident conclusions.

While Ukraine has a lot of bottom-up initiatives with the involvement of local communities, these alone cannot sufficiently respond to the many challenges and limitations. Government programs must be implemented with the support of international actors and with the involvement of various NGOs both at the national and local scales. Developing a comprehensive dataset and database that would provide a clear understanding of the ecological context and challenges will be of great value in informing decision-makers and other stakeholders on what the priorities should be for the Dnipro River basin or any specific area or region. Indeed, the issues of data collection and data scarcity are closely related to the current situation, with experts who are able to collect and interpret the data competently. With the scale of the damage to the natural environment from the ongoing russian invasion, the need for skilful professionals only grows. Developing training programmes for ecologists, including water-related experts, in particular, should be considered seriously. Within the realm of ecology in general, more attention should also be given to river-related ecosystems and species (fish, amphibians, insects, water birds, mammals and so on).

That is why, in order to study, maintain and enrich biodiversity within Dnipro River basin after the end of the war, the following steps are proposed in Table 4 below.

Table 4. Proposed steps for biodiveristy preservation and enrichment

1.	*Develop training programs* for ecologists, biology conservationists and water related experts.
2.	*Revise and update biodiversity data* (where possible) as soon as the war ends, providing a more accurate picture of the current situation of biodiversity within Dnipro River basin.
2.	*Identify the most valuable* and endangered species (animal, plants, and fungi) and elaborate a precise conservation strategy.
4.	*Propose and establish new Protected areas*, based on available spatial information about biodiversity.

The recently adopted Kunming-Montreal Global Biodiversity Framework, alongside the EU Biodiversity Strategy for 2030, advocates for a minimum of 30% of land and sea to be safeguarded or rehabilitated to bolster biodiversity, improve ecosystem functions and services, and ensure ecological integrity and connectivity (UN Environment Programme, 2022; CEOBS, 2023). Based on our analysis of existing data, described in detail in *2.1. Natural environment and biodiversity*, Table 5 illustrates the shares of protected areas within the Dnipro River basin, compared with average data for the EU-27 provided by the European Environment Agency (2023).

The existing overlap of protected areas is due to the fact that the first step for the creation of the Emerald network was the inclusion of all national parks and reserves. In addition, some of these areas overlap with territories protected by The Convention on Wetlands. All this means that the aforementioned PAs are the most protected under Ukrainian and international laws.
In addition to those areas accounted for in the table, there are 58 areas that had been proposed for adoption before the war. If they are accepted, the total Emerald network will cover 16.4% of the Dnipro River basin. Of course, the aim of ecological organisations in Ukraine, such as UNCG (a main actor in the process of assessing, suggesting and protecting the areas), is to expand the Emerald Network to 20% of the area of Ukraine and elaborate feasible management plans for the sites. Unfortunately, the last time that suggestions for a new Emerald network area were made was in 2020, but they are still not approved, probably because of the war situation.

Besides all the pros of the Emerald network, there is one major weakness - currently, no legislation exists in relation to agricultural activity, which occupies most of the territories defined for the Emerald network. Despite being a core sector of Ukraine's economic activity, agriculture has a number of counter-effects on ecology and biodiversity. To become more climate-proof, Ukraine will need more eco-friendly guidelines for agriculture production and more natural areas protected on a national level. National parks and reserves restrict functions and possible use of the land and water. A similar law (or change of a current one) should be implemented in order to protect the Emerald network from agricultural activities.

Table 5. Protected areas as a share of total area in Ukraine and the EU-27

Protected Areas	*Ukraine*	*EU-27*
Nature Reserve Fund (or equivalent for EU-27)	*7.50%*	*7.40%*
Emerald Network	*13.16%*	*18.60%*
Ramsar sites	*0.62%*	
Total (taking overlaps into account)	***18.68%***	***26%***

4.2.2. Protecting ecology and biodiversity

According to the Global Risks Report 2023 by the World Economic Forum, biodiversity loss and ecosystem collapse is one of the top five threats to the world over the next decade. Protecting ecology and biodiversity cannot be ignored. In order to maintain and enhance biodiversity in the Dnipro River basin and in the whole of Ukraine, to recover existing protected areas and to develop the network of protected sites further the following steps are suggested in Table 6.

All the aforementioned suggestions aim to enhance the biodiversity and the network of protected areas within the Dnipro River basin. The quality of nature on the river itself is one of the most deteriorating due to the continuing war. That is why, and because of its great importance, all suggested activities, along with others that will bring for building back a more resilient nature, could be implemented in a full-fledged strategy for ecological restoration of the Dnipro River after the war.

Table 6. Step-by-step guidance on protected areas in Ukraine

1. *The restoration and expansion of protected areas*: Most of the protected areas that had been devastated by war need to restore the human resources and technical capacity of their administrations to make possible the recovery of the areas from the damage. In order to extend the number of protected areas and improve their interconnectedness, a significant amount of human and financial resources is required. Namely, to estimate the real situation of the ecosystems and to propose proper new protected areas that enhance the environment.
2. *The de-mining of environmentally sensitive areas*: In order to ensure safe physical access to parks, reserves, and other protected areas, for visits or science work, a proper way of de-mining should be done. It can be part of a national de-mining strategy, with focus on mine actions for environmentally sensitive clearance. In addition, a framework of area prioritisation can be developed in order to start from the most urgent territories.
2. *The observation and documentation of war's impact on ecosystems and biodiversity*: It is mandatory after the end of war to conduct a series of desk and on-field research that aims to document the existing and estimate the future impacts of the invasion on ecosystems and biodiversity. For this purpose, the existing public data on biodiversity and protected areas can be used and compared to actual data gathered via field trips, satellite imageries and other sources of knowledge such as local scientists and crowdsourcing platforms. Having the knowledge of nature is the best way to interact with it in a proper manner.
4. *Ensuring recovery for a green and resilient Ukraine*: The recovery of the whole of Ukraine should be dominated by concepts of green recovery, embedding environmentally positive practices in restoring destroyed urban areas, as well as implementing best practices for sustainable nature restoration and expansion of protected areas. Such a comprehensive process should be established under the principles of using the proper level of knowledge and expertise, including local communities, transparency, and guidance by international biodiversity obligations such as the Kunming-Montreal Global Biodiversity Framework.

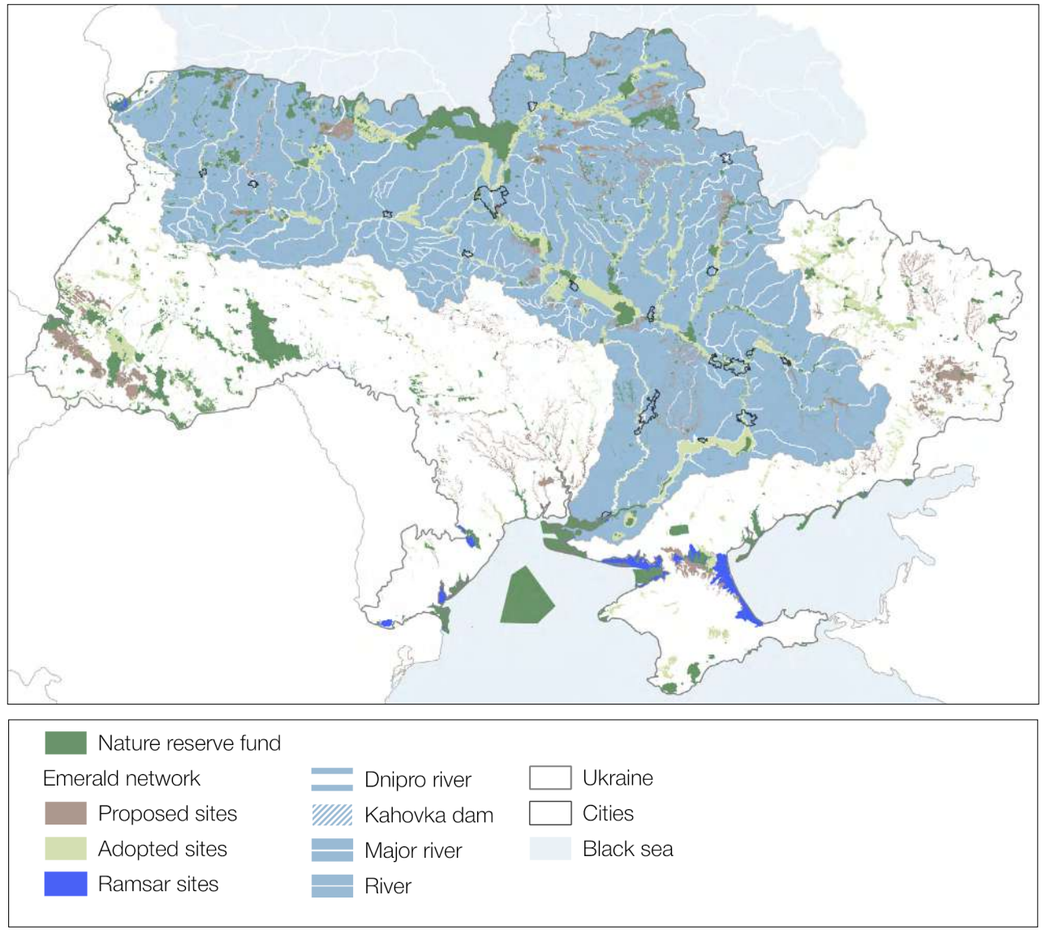


Figure 2. Map of Ukraine's Nature Reserve Fund and other protected areas, and the Dnipro River basin. Author: Elaborated by Ro3kvit and Greenpeace CEE

"River ecosystems recover faster than terrestrial ecosystems because water moves and self-purification processes take place faster. The Dnipro is our national pride, our relic from Cossack times, it is the largest water artery of our state, and Ukraine should be interested in its restoration as soon as possible."
– Serhii Chumachenko

Interviewing **Olena Fateieva**

Designer, ecoactivist
Lives in Kyiv

I was born and raised on the left bank of the Dnipro, making it an integral part of my homeland and my place of strength, not only the river itself but also its islands and banks. For me, Kyiv makes no sense without the Dnipro and access to it.

As far back as I can remember, I have spent time on the banks of the Dnipro, on Mykilska Slobidka, and on the beautiful sandy beaches that stretched for kilometers. I recall when private houses stood there, and residents owned boats for fishing. I even remember several significant Dnipro floods in the 1980s that forced evacuations.

I have seen the Dnipro in all its varied states. In winter, we would skate on the ice or check the fishermen's catches. In spring, locals cleaned the banks. I remember the Dnipro in autumn when the banks turn colorful and the great bird migration begins. Nowhere else in Kyiv will you see so many birds, and this remains constant as we, the community, and officials change.

Since 2000, I've witnessed the community's battles against real estate developers. I was content until heavy machinery arrived on my beloved Dnipro bank, destroying trees. I inquired about what was happening and discovered this left bank area, Horbachykha, is reserved for a protected area. It's the last example of the left bank's historical appearance. Before the Vyshhorod Dam, the left bank flooded yearly, creating dunes; the river banks were completely different. The last remnants of those dunes and floodplain forests are in Horbachykha. Many of us ran to stop the destruction. We formed the Save Horbachykha initiative and began opposing the destruction and construction.

We insist on creating the Horbachykha reserve to preserve the ecosystem, crucial for Kyiv's climate and beyond.

We've been defending Horbachykha with the European Union, whose letters to the Ministry of Ecology and Kyiv City State Administration helped stop construction progress. The future reserve spans 100 hectares of banks and floodplain forest, with 14 hectares of willow varieties. Lakes are home to beavers, including the rare black beaver. We have many herons - in summer, you can see three species simultaneously. There are numerous Red Book birds and plants, more than 60 species protected by international conventions. It's unique to see so many animals, plants, and birds in the city center. Dutch architects said, "You have a naturally fixed sandy coastline, you're blessed! You don't need to touch it, concrete it, strengthen it – it's a natural treasure."

Raising awareness among communities and society is crucial. People need to know what they have, what they might lose, and how it will affect their lives.

We have a legally formalized reservation for this land, and I put up boards stating this, indicated the area, and listed what lives there. Three years later, when a tractor comes, local groups raise a fuss. People have gotten used to it and react. I don't have to run to the shore every time because I'm not the only one who cares.

Ukraine lacks environmental education. When I told the Kyiv City Council about the Bern Convention and Commission on Horbachykha, they didn't know what that was. They wore fur coats to meet the commission in Europe. The chairman sent me a photo of them in fur coats next to him in a modest jacket and asked, "Do these people have anything to do with the environment?"

We have weak legislative protection of state interests. We have a land status and scientific justification for creating a reserve. The land is communal property, needing one City Council vote. Documents show such a vote in the 90s, so we just need to submit these and new justifications to the Environmental Department.

But the City Council and Department boycott it, demanding a public vote. We held one with 640 unanimous votes, but local deputies block community decisions. We're trying at the state level. Zelenskyi gave the go-ahead, the Verkhovna Rada voted, the president and prime minister support it, the Ministry of Ecology worked on it with scientists' justifications. But the state needs the landowner's consent, and the land is communally owned by city council deputies!

Corrupt officials can block efforts by the community, state, ministries, or scientists. The only solution is strong legislative protection of state interests, above community or city council decisions.

The Dnipro is a national and European interest. Our main task is to keep the Dnipro in the best condition possible. Water is life. Where there is water, there will always be life.

4.2.3. Developing biodiversity corridors

In recent decades, Europe has faced the process of creating a pan-European ecological network and its components, which are national ecological networks (Jongman, 2011; Mudrak, 2018). Ukraine has also been developing a national ecological network. A legislative framework is being created, a network of nature reserve fund objects is expanding, and ecological corridors of national importance are designed, namely five latitudinal and five meridian eco corridors. From the list below, we can see that Dnipro Ecological Corridor is one of the largest. It starts from the northern borders of Ukraine and ends on the Black Sea coast, crossing three natural zones – Forest, Forest-Steppe and Steppe.

At the same time, the Dnipro meridional corridor crosses all the latitudinal corridors of national importance (Dnipro, 2008; Mudrak, 2012). A large number of different types of natural and semi-natural ecological systems (forest, meadow, steppe, wetland, etc.) are found within the limits of the Dnieper Ecological Corridor. Due to this, representatives of more than half of Ukrainian fauna and flora live on its territory. Dnieper Ecological Corridor is one of the three main migration routes for birds. Each year, millions of birds use it. Despite the fact that the Dnieper is transformed into a cascade of reservoirs, the river is of great importance in preserving fish species diversity (Solomakha et al., 2020).

Dnipro River is the foundation of the whole ecological corridor. It gathers the water from all its tributaries, lakes, and groundwater, forming a water body that greatly impacts the natural and urban environment. Together with its major tributaries, it creates a network of rich biodiversity and protected areas. In order to prove this statement, a 10 kilometres buffer from each side of the river is calculated, as well as 5 kilometres buffer from each side of the Dnipro River's major tributaries - Inhulets, Desna, Pripet, Oril', Vorskla, Samara, Teteriv, Sula, Ros, Psel. The total area of buffers along these rivers covers just 13% of the total area of the Dnipro River basin. Despite this small percentage, it is estimated that the area holds:

- *71% of all recorded animal species* within the Dnipro River basin, as well as 66% of all protected and rare animals;
- *79% of all recorded plant species* in the Dnipro River basin are registered, as well as 53% of all protected and rare species of plants;
- *57% of all recorded fungi species* in the Dnipro River basin, as well as 76% of the protected and rare species, are registered within the buffers;

All these numbers are proof that the Dnipro River and its major tributaries are the most important biodiversity corridors, with the greatest amount and variety of species. In order to achieve ecosystem resilience in war times and beyond, it is necessary to conserve the richness of biodiversity. One of the major conditions for this is to have clean water. Even before the war, this was not the case with Dnipro, as researched in detail in 3.5 Water Disruption and Pollution.

River ecosystems have the ability to self-clean. However, they can self-clean under the condition that they are not continuously polluted. Many factors will also affect this - water level, precipitation regime, and temperature regime (Ukrainska Pravda, 2022).

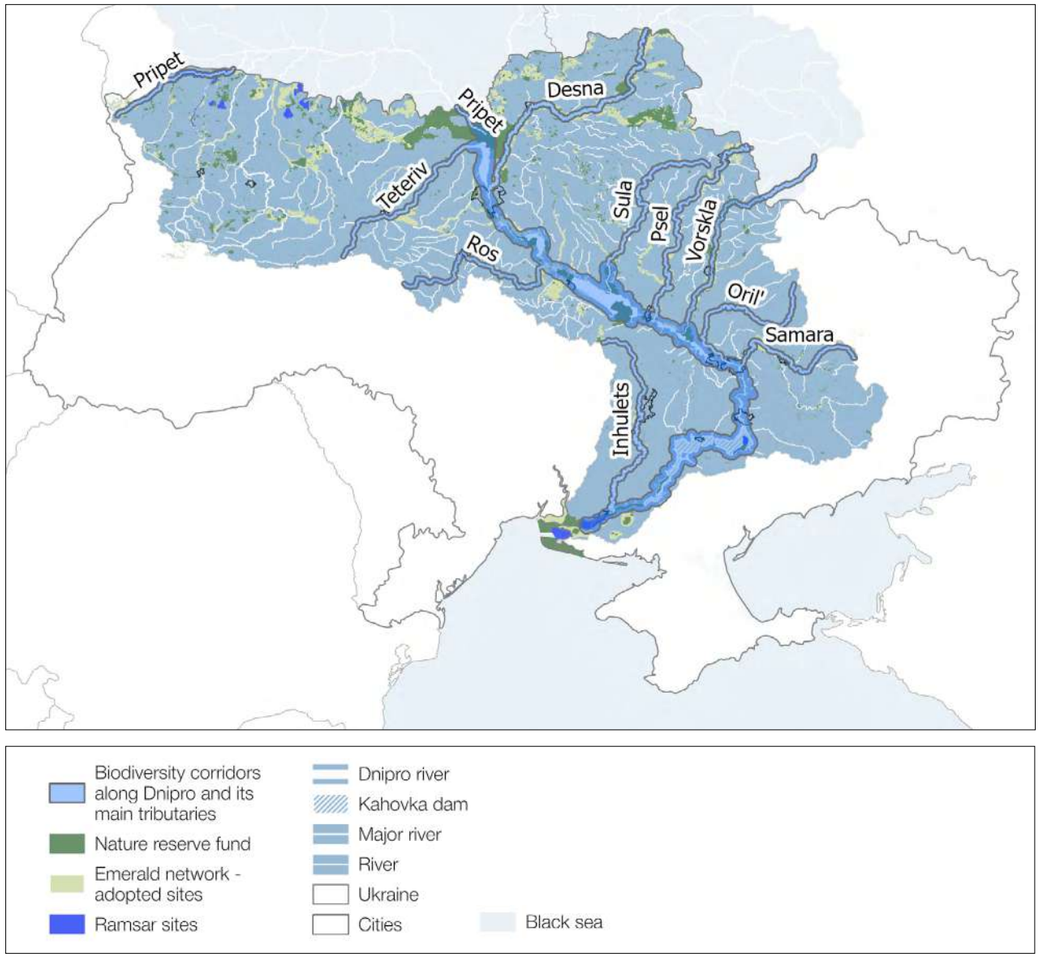


Figure 3. Biodiversity corridors along the Dnipro River and its main tributaries
Author: Elaborated by Ro3kvit and Greenpeace CEE

The first step for achieving clean water is to develop a properly functioning system of water treatment facilities to prevent the discharge of untreated sewage. The second step is to implement nature-based solutions in order to overcome the already existing pollution on the Dnipro. This could be to create floating islands of plants and algae that absorb pollutants from the water, including heavy metal compounds, phosphates, nitrates, nitrites, and other dangerous substances. Last but not least, constant monitoring of river pollution should be conducted.

As stated by the Convention on Biological Diversity, along with pollution, overexploitation of bio-resources, and the destruction of landscapes as a result of agricultural activities, one of the major threats to biodiversity in Ukraine is the fragmentation of landscapes by human infrastructure and urbanisation (CBD).

Spatially, the Dnipro River is the unifying foundation that connects the different elements of the Nature Reserve Fund, as well as the Emerald network and Ramsar wetlands. Heading out of the Dnipro River as the main axis, there are the other lineal areas that run mainly along the (major) rivers in the Dnipro basin, forming a network of protection corridors. If we analyse closely the importance of the Emerald network corridors, whose main purpose is to ensure the conservation of the most valuable and typical components of landscape and biotic diversity, we estimate that within the network are registered 439 of all 524 protected species of animals, 476 plants out of 589 protected and 35 of all 38 protected or rare fungi.

This underlines the importance of the Emerald network and the need for its expansion in order to protect endangered species and ecosystems via the creation of ecological corridors. Although the Dnipro River is the backbone of the whole system of protected areas and biodiversity, not all parts of it are included in the Emerald network. According to Oleksii Vasyliuk, an ecologist of the UNCG (Ukrainian National Conservation Group), the reservoirs are considerably less rich in species compared to the upper parts of reservoirs, where the natural conditions of the Dnipro are preserved and which were excluded from the formal Emerald Network. That is why we would like to discuss what different protected statuses should be applied to the river and how this ensures the intactness and persistence of biodiversity and protected areas along its flow.

In order to have an overall network of biodiversity corridors, we suggest connecting green and blue structures, strengthening the original streams and valleys towards the river.

Green corridors: eco-corridors	Blue corridors: for fish and water flow
Zoom into the specific topography zones to bring more detailed recommendations on the improvement of protecting the environment.	Use the potential of the Black Sea as a connecting point between the Danube and the Dnipro Rivers
Zoom into the protection of specific species to bring more detailed data and recommendations on the improvement of biodiversity.	Make a connection to the Azov Sea (primarily blue) and to the natural zones in the Donbas (primarily green)
	Connect northern and southern ecological typologies

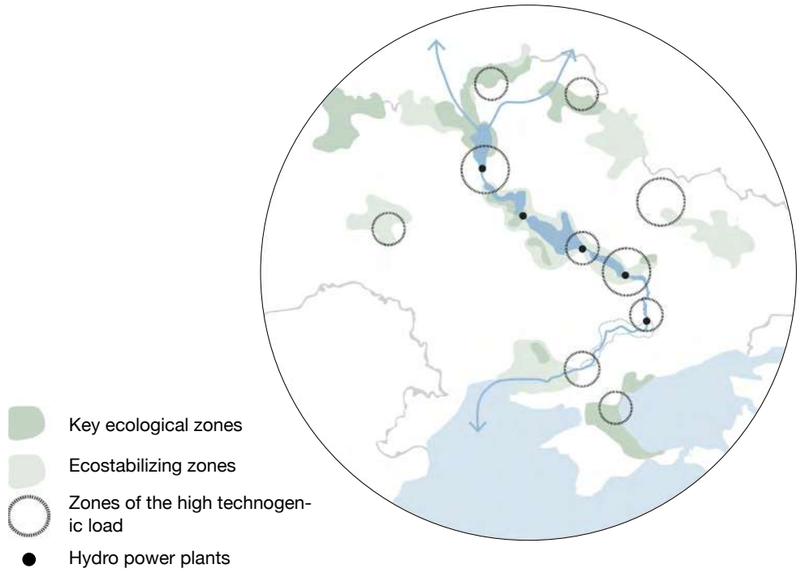


Figure 4. Key ecological zones along the Dnipro river and areas of technogenic load.
Author: Elaborated by Ro3kvit and Greenpeace CEE

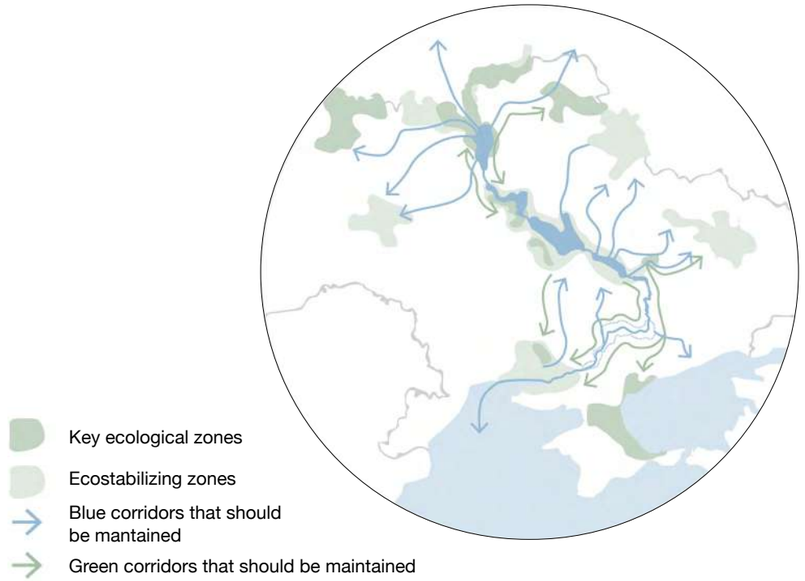


Figure 5. Key blue and green corridors that should be maintained to protect the Ecological network.
Author: Elaborated by Ro3kvit and Greenpeace CEE

4.2.4. Re-wilding the Dnipro River

It is time that designers use the power of nature instead of trying to fight it.

Once the PAs are established and the biodiversity is constantly monitored and conserved, more targeted steps can be implemented. Eventually, the tension between human activity and the natural environment in its pure form cannot be eradicated. However, we as humans should strive to help bring the environments we destroyed, damaged or fragmented back to healthy life. Sometimes, this means just leaving nature space, and it will do its job. In other instances, giving nature a space to breathe, so to speak, becomes a job for planners, urban designers, and landscape designers. One thing is certain: there is a lot of potential for improvement to make our riversides more friendly for the species that live off of them and, eventually, for ourselves.

Ecosystems help to overcome the war's consequences, and such natural processes cannot be replaced with technological ones. Plants, soil organisms, bacteria, and even some animal species carry out biological remediation, such as extracting hazardous substances from soils and water bodies accumulated during munitions explosions when manmade objects burn. Reservoirs, wetlands, and floodplains filter polluted waters and accumulate pollutants. Waterways help dilute those pollutants and transport them downstream to sea. En route, some substances are absorbed and processed by aquatic organisms into less toxic compounds. Forest ecosystems filter out atmospheric pollution and improve the quality of air polluted during combat. Grassland biotopes protect damaged soils from wind and water erosion, restore soil formation, and store atmospheric carbon dioxide. The restoration of grass cover not only improves the process of soil formation and elimination of pollutants but also stabilises climate. Grass-covered soil blocks surface runoff, a process which could carry pollutants into water bodies. All of this immense work is carried out simultaneously by billions of living organisms, and they do this work simply because they are living their lives.

One possible solution to our many environmental challenges that take the above into account is the naturalisation of rivers and their banks, the restoration of natural biotopes, or, in simple words — rewilding. Rewilding can offer an answer not only to those territories that have been suffering from heavy anthropogenic pollution for years and decades, but it can also be a strategy applied to overcome the more pressing and more devastating consequences of the ongoing war and hostilities, recovering the lands turned unsuitable. A common practice in many countries around the world, renaturalisation can help to improve the state of Ukraine's environment while increasing the surface area of natural landscapes and ensuring clean air, water, and a more comfortable microclimate. In seeking natural restoration strategies, Ukraine will more effectively achieve the nature conservation goals laid out in the framework of international treaties, in particular, the Convention on Biological Diversity (UWEC, 2023).

i. Renaturalising river embankments

One way of re-wilding, particularly important for our urban environments, is the renaturalisation of river embankments. The embankment and the river work together: how is the water used, how are the embankments used and planted? What kind of trees, plants, water plants and groundwater streams do we have and could we have? What role can plants and trees have in enforcing the embankment? An agricultural area next to the river provides an unhealthy vegetation buffer strip that is needed for natural, clean water. A concrete wall (dams) or sewer and water waste pipes make it much worse (Friends of Chicago River).

Specific attention must be given to urban areas. The embankments are often taken over by roads, buildings and other human activities. By rethinking the Ukrainian cities and villages at the river, we should take a few simple suggestions into account. The cities should develop green areas along the river, at least on one side. This green area can 'jump' to the other side, depending on the size of the river at that point. Green can also be used to strengthen the embankments against erosion: use the right local plants and trees and avoid erosion with concrete. And, of course, we should invest in better waste management and stop polluting the river with waste from households and industries. In cities, the embankment design is even more fragile in terms of ecology. Some reference examples from Sasaki might help to rethink city embankment planning (Sasaki.com)

Turning back to a 'natural design' of the embankments of the river will make the water cleaner and the drinking water cheaper. Also, the natural habitat of different species (insects, fish, and several mammals) will improve, which will make us a healthier bio-system.

ii. Removing dams

Few things have such a fundamental impact on a river as a dam. Dams block the movement of fish and other aquatic species, inundate river habitats, impair water quality, and alter the flow regime necessary to sustain river life. As dams age and decay, they can also become public safety hazards, presenting a failure risk and a dangerous nuisance (American Rivers).

The construction of the cascade of dams on the Dnipro River has led to the destruction of the whole biome of long-term flooded ecosystems: forests, meadows and marshes. Thirty-four plant communities from the Ukrainian Green Book have disappeared from the floodplain territory. The plant kingdom lost 14 species from the IUCN Red List of threatened species, 27 species from The European Red List, 14 species from the Bern Convention and 84 species from the Ukrainian Red List. The study 'The Dnieper River Cascade Of Reservoirs As A Main Reason Of Biodiversity Loss', 2015 shows that secondary ecosystems are formed in the condition of adventive plant species complete dominance (Desert False Indigo – Amorpha fruticosa, Water Soldier – Stratiotes aloides) with actual displacement of the indigenous vegetable biodiversity.

Around the world, the removal of dams and barriers has become a common solution to the restoration of natural biodiversity. To date, more than 2000 dams in the USA (American Rivers, 2024) and over 8000 dams in Europe (We Are Dam Removal Europe) have been removed in order to restore free-flowing rivers, enhance biodiversity and allow endangered fish to breed. Among the recent examples, the largest dam removal in Europe was the 36-metre-high Vezins Dam on the Sélune River in France in 2022 (Water News Europe, 2019). According to research, the removal of the dam resulted in a number of positive effects on nature, including the return of rare fish species, the decrease of river temperature by 2 degrees C, the return of vegetation to the banks, and the natural transit of previously trapped sediments.

Coming back to the Dnipro River it is interesting to note that Skrypnyk and Andreieva (2015) suggested the option of dismantling the Dnipro River cascade of dams and reservoirs as a possible solution to the floodplain biodiversity loss. Of course, the scale of the Dnipro River dams is much bigger and dismantling the Dnipro River reservoirs' cascade is a very radical and challenging decision that needs a lot of discussion and proper estimation of cost, but also of social, ecological, and economic effects.

While it seems rather unrealistic, and perhaps not very relevant to suggest this option for the Dnipro River, both due to the scale of the dams and reservoirs, but also because of the untimely manner of such a proposal in a wartime context. Nevertheless, we believe that this question requires some deeper consideration and research, to provide for alternative solutions for the long-run. In the long run, there is a rationale to take into account both the risks of dam weaponisation revealed by the war, but also the more natural fact that the Dnipro Cascade will inevitably become old and weary, putting additional pressures on its safe and efficient use.

That said, it is also important to remember that the Dnipro River cannot be abstracted from the rich hydrgraphic network of its basin. The removal of smaller dams on the many tributaries of the Dnipro River should also be considered.

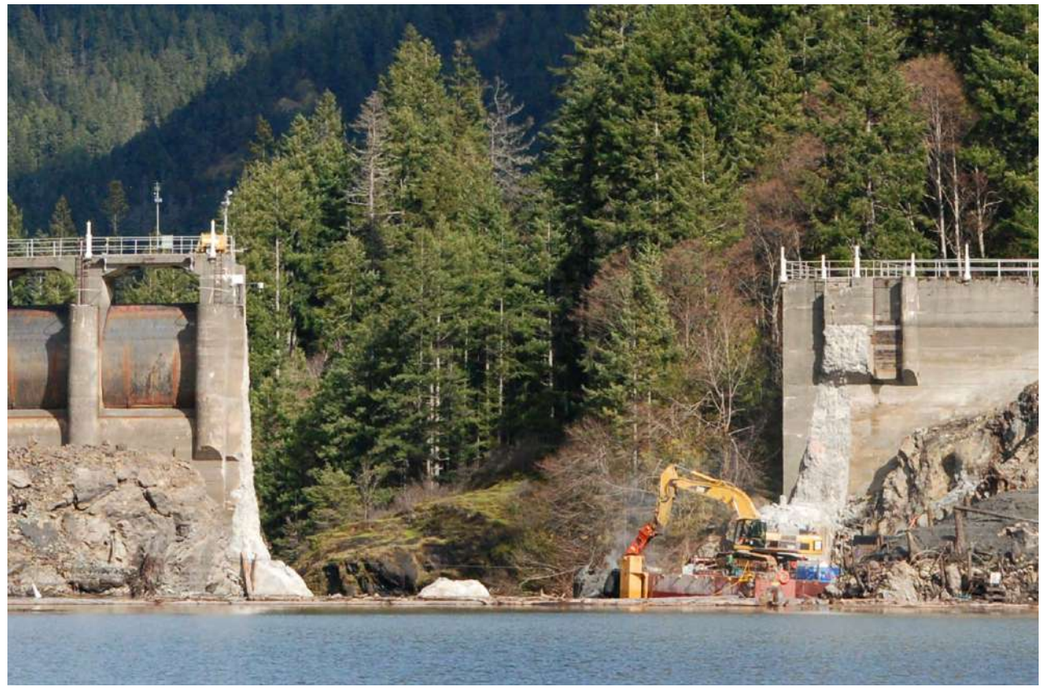


Figure 6. Photo of the Glines Canyon Dam, the largest dam ever to be removed, shown mid-demolition in 2012.
Author: Olympic National Park; Source: Wikipedia.org (Public Domain) – Photo chosen for illustrative purpose

iii. Restoring wetlands

Wetlands are vital for our survival. Yet, the world has lost 87% of its wetlands since 1700 — and they continue to disappear at an alarming rate, even today. 35% of the world's wetlands have been lost since the 1970s. And the continued rate of degradation and loss of these life-supporting ecosystems — because of human activity — is staggering. When wetlands are degraded, the broad range of benefits they produce begins to deteriorate. Eventually, they vanish altogether. Among the world's most productive environments, they provide essential benefits and serve us in many ways, described in Table 7 (Ramsar Convention, 2021).

According to Oleksiy Vasyliuk of the UNCG, *"War brings the most devastating losses to forests, secondarily so to steppes and meadows, and only then to other biotopes. That said, wetlands avoid most suffering, as they are usually bypassed by military activities. When risked, wetlands are barriers to enemy vehicles, sometimes absorbing them forever. All important wetland functions that play a role in climate formation, regulating water content in rivers, and the preservation of organic matter accumulated in peat for thousands of years remain intact. The same is true for the services of all flooded ecosystems"* (UWEC, 2023).

Despite the aforementioned assumptions, it should be noted that all Ramsar wetlands located on the Dnipro River are situated in the south part of the river, very close to the frontline. Related to all different types of war damage and its consequences for nature, described in detail in 3.4. Ecocide and Environmental Disaster and 3.3. Kakhovka Dam Destruction has an enormous impact and negative pressure on the wetlands' ecosystems. That is why wetlands restoration should be revised and prioritized if necessary. The restoration of wetlands yields many far-reaching benefits – Table 8 (Ramsar Convention, 2021).

Table 7. Benefits of wetlands

Wetlands provide food and water, often in areas of extreme poverty: almost all the world's consumption of freshwater is drawn either directly or indirectly from wetlands.
Wetlands are critical to biodiversity with 40% of all the world's species living and breeding in these environments.
Wetlands serve as an important source of employment and income, providing for more than a billion jobs and services.
Wetlands enrich quality of life, offering opportunities for relaxation and culturally empower local communities.
Wetlands are vital in the fight against climate change, storing more carbon than any other ecosystem on the planet.

Table 8: Benefits of restoring wetlands

Restoring lost or degraded wetlands presents a valuable and cost-effective opportunity for society to recover and enhance benefits for human health and well-being.
The total value of benefits that flow from a restored wetland is often several times higher than the cost of restoration.
Restoration interventions can bring back lost ecosystem services,and increase the heterogeneity of wetland functions and biodiversity.
Wetland restoration can be a cost-effective, long-term strategy for simultaneously achieving conservation and development objectives.
Maintaining and restoring wetlands also leads to cost savings when compared to manmade infrastructure solutions in many cases.

Figure 7. Photo of wetlands on the Dnipro River in the Kaniv Reservoir
Author: Petrochenko Viktor; Source: Wikipedia.org (CC BY-SA 4.0)

4.3. Green and diversified economy

Introduction

For centuries the Dnipro River has been part of the economic development. In the old times, the river was an economic driver because of fishery, trade and transport. In Chapter 2 this historical context has been described. In Chapter 3 we described how during the Soviet period the Dnipro River transformed. It was also used as an economic driver, but now as part of a concept of industrialisation.

The economic value of the Dnipro River has been shrinking over the last few decades. Industrial activities along the embankments have slowed down. Large industrial areas all around the country are out of use, and cities along the Dnipro River are struggling with the effects. The potential growth of economic activities in existing industrial locations. Therefore, parts of the industrial areas are being sold or rented out for different small industries, storage or consumer businesses like car repair or malls. Fragments with different owners, contracts, and life span.

The ports play only a small role due to the cascades of reservoirs and inefficient water transport. But the port areas are closed zones and residential areas are disconnected to the river, even when the harbour activity is low. One would expect that the limited industrial and port activities would change the urban planning approach and, therefore, play a positive role in ecological development, but this effect is not visible yet. More changes and active decisions will be needed. Inspiration and design guidelines can be formed for all hromadas along the river bank to improve their embankments.

Further magnifying the challenges in modernisation and reconstruction, most of Ukraine's major enterprises or industries, which have suffered from the war, have become uncompetitive due to obsolete technology, high energy intensity and a lack of funds for their development. Thus, Ukraine's economic recovery will require both reconstruction and modernisation. One example of this is Ukraine's steel industry, which has suffered the loss of two of its biggest factories in Mariupol. The implementation of modernising this industry would require an investment of $6.6 billion from Ukrainian companies (CSIS, 2023).

Addressing the economy at large is not the prime objective of this report. But the challenges described above make it impossible to avoid discussions about alternative visions. Below, we propose some of the key principles and ideas for consideration.

4.3.1. Diversified economic activity

We are facing a new era. In terms of new economic developments, we must look at a more diverse and green economy related to the Dnipro River. The river crosses different parts of the country and has different economic potential. For the cities along the river, the river defines identity and quality of life. Cities attract the best companies and people only when urban areas are comfortable, and the Dnipro River can play an important role in this. The human connection of the city and neighbourhoods to the water is crucial in economic development.

This also connects to the huge challenge of demographic changes. We are more than aware of the outflux of men and women that will be needed for a healthy economy. The demographic changes due to internal and external refugees and the killings of (often young) soldiers will have a massive influence on industries and cities. Industries, businesses, institutes, cities: it can be expected that all will struggle and compete to find enough people. The expectation is that working environments that are modern and healthy will attract more employees.

For the industry, it can be advised to rethink not only the type of industry but also the location. While making new recovery or general plans for the cities, we strongly advise using this momentum and making strategies to allocate possible industries further away from the river. First of all, we recommend 'greenifying' the industry so it develops towards and within the EU standards. Besides this positive approach, it also helps to give more restrictions to the industry in terms of technology and location: both the city and the water will become cleaner and more comfortable.

In the (south-)eastern part of the Dnipro River, we need to look at the Donbas area specifically. After liberation, this area and cities and villages in the Donbas region will need to reinvent themselves. The historic network with Russia will be disconnected for decades. Despite this geopolitical change, industry will most likely still play an important role. There are still sources in the ground, still some of the running factories, and engineers and workers. However, in global changes in the economy and the change in positions in Russia, China, and India, economists advise the departure of the mono-functional industrial approach and shift towards a diverse model. The strengthened EU connection and the importance of the Green Deal will make a circular economy one of the possible vectors.

In the Southern part, the natural quality, the beauty of ecology and geography most likely the main drivers. Nature development and eco-tourism will be described in the following chapters. And maybe the water transport can start playing a role again, depending on the decisions to be made on the Kakhovka Dam. And of course agriculture, as it will also be in the other parts.

The agriculture is an important part of the economy of Ukraine. Although it is often seen as a healthy economy (the products are nature-based), also agriculture in Ukraine (as in many countries) is a polluting industry that can and should become more nature-oreniented (see also *4.5. Modernised agriculture*).

Last but not least, it is recommended that the size and location of the ports in the cities be looked at. Reallocating is expensive, but at least revisiting zoning plans for non functioning economic areas should be more often seen as an option. Quite a few cities will show opportunities in the port structure to improve the port activities at places where it does not affect the city life and flora and fauna much.

Figure 1. Infographic map of the current economic situation in the regions along the Dnipro River.
Author: Elaborated by Ro3kvit and Greenpeace CEE

Figure 2. Infographic map, proposing a diversification of economic activity, shifting regional division-based economy to the net-work based economic models. Author: Elaborated by Ro3kvit and Greenpeace CEE

4.3.2. Sustainable Development

We believe the future of the Ukrainian economy can and will be green. For mankind, for the next generations, for flora and fauna, and for natural balance, sustainable solutions will leap Ukraine forward to a new economic era. For this, we strongly advise you to rethink the position of the industry in all relevant layers. Industry and man-made activities have alternatives. Nature often does not. We propose several basic guidelines for new economic developments (see Table 9).

Table 9: Recommendations for Sustainable Development (SD)

1.	*Prioritise the emerald network above the industry*: When there is a possible conflict between nature and industry, the natural main structures should be highly rewarded. For the use of water by households, agriculture, industry and wastewater, we do have alternatives.
2.	*Create policies and support programs*: On all governmental levels, support can be given to invest in sustainable solutions. Local, national and international governments can give incentives via a tax reduction and land use to greenify the industries, including transparent monitoring. Also, in tenders, clear and ambitious sustainable development goals can be included for investments and developments.
2.	*Networks*: Develop regional networks to create identity, collaboration and guidelines for economic developments related to the geographical and human-developed context. Governments can help create awareness programs for both industries and civil society to create local knowledge about alternatives for the existing industrial complexes.

4.3.4. Local Economic Development

Table 10: Recoomendations for Local Economic Development (LED)

1.	*Diversify the economy*: In these times, the economy relates more and more to urban areas. Along the Dnipro River, some of the main Ukrainian cities are located. The quality of life and work in these cities will define the economic potential. A diverse city economy is key for this.
2.	*Update zonign plans*: Rethink locations for businesses and industry. Things do not change overnight. A part of the industry will stay and produce less clean, we assume. For these more polluting industries, we must rethink locations. When (re-)allocating the industry or further away from the river or outside the city, you will gain both a clean city and clean water. By choosing the locations for industrial activities or the green zones in and around industrial areas, the effect of polluting or disturbing activities can be limited. Location studies can be needed, with a maximum long-term effect. As mentioned in 4.3.1, port locations and activities can be reviewed and redesigned. Since activities have changed since soviet times and will change more, we advise cities to relook at the needs and size for port and harbour activities.
3.	*Create guidelines for local hromadas*: Develop information and design guidelines for all hromadas along the river bank to improve their embankments. See chapter 5.3, Helpful guidelines for hromadas.

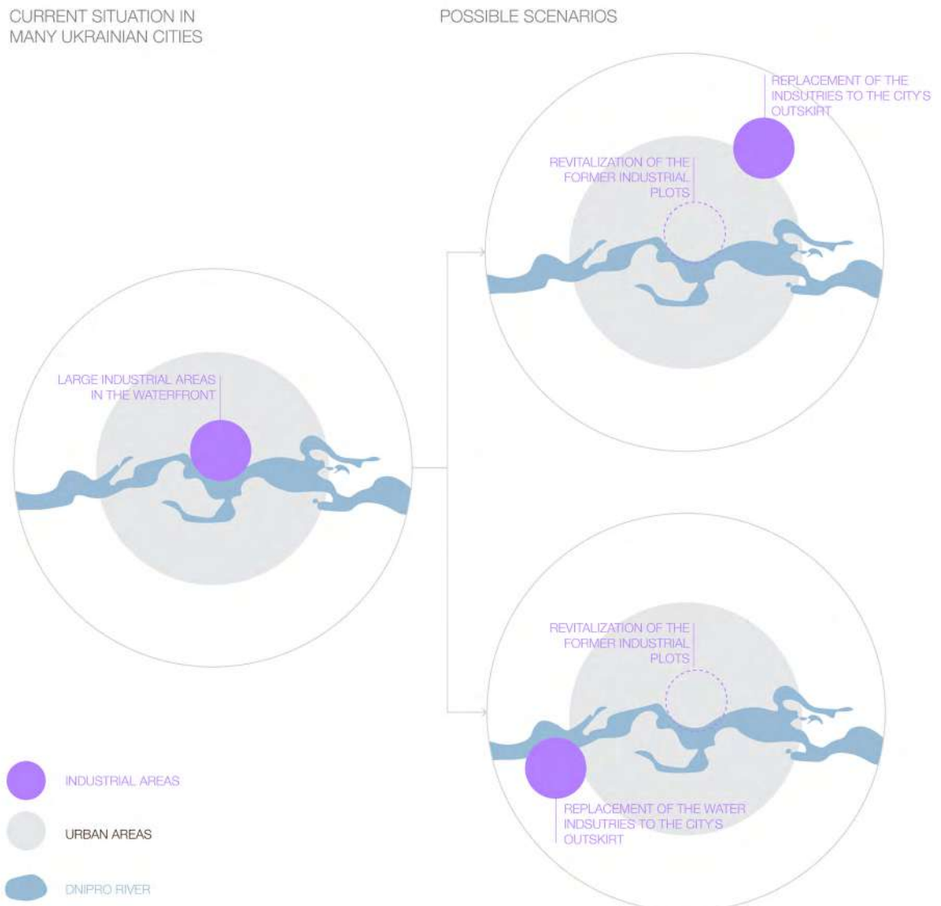


Figure 3. Possible scenarios for the displacement of industrial sites from the city centre
Author: Elaborated by Ro3kvit and Greenpeace CEE

4.4. Resilient energy system

Introduction

A reliable supply of fuel and electricity is vital to the proper functioning of any country. In times of peace, but even more so in times of war. Prolonged energy insecurity would cripple the economy, exhaust the population, drain the strength of the army and inevitably lead to defeat while causing significant humanitarian and environmental damage.

As discussed throughout Chapter 3, since the russian full-scale invasion in 2022, Ukraine's energy sector has suffered unprecedented and severe losses. Already in 2014, Ukraine has had to deal with an energy crisis due to the Russian occupation of the Donbas region — Ukraine's largest industrial region and the place of several major energy power plants. In 2022, however, with the Russian full-scale invasion of Ukraine, the damage to the energy sector has taken a very different direction, as energy infrastructure has become a prime target of Russian missile attacks — an attempt to paralyse both Ukrainian industry and transportation nodes, as well as the morale of the population, as millions have found themselves without electricity supply and heating.

Previously, russia mostly aimed to destroy energy transformation objects and transmission nodes, with 90% of attacks directed at the objects of the systemic operator Ukrenergo. The most recent Russian attacks (as of April 2024) have demonstrated a significant shift in attack tactics. Concentrated strikes using various types of missiles and drones have been directed at energy generation infrastructure, leaving most Thermal Power plants and several Hydroelectric Power stations damaged or destroyed (Economichna Pravda, 2024).

For a state, it is naturally much easier to control and operate a centralised system. This explains why most, if not all, totalitarian countries, or countries that have been under totalitarian rule, have a high level of energy concentration, with several huge industrial objects. Ukraine is no exception, as its energy system is mostly inherited from the Soviet Union. While it has its advantages, the system comes with a number of limitations. Gradually, Ukraine has lost both generation and consumers, as well as power lines.

With the war, damages to the network have become so vast that they are hard to quantify and assess. These damages and losses, while ravaging themselves, have also revealed the fundamental weaknesses of Ukraine's energy system: too centralised, too dangerous, too inefficient, and too costly. The destruction of major Thermal Power Plants confirms this thesis. Their reconstruction to full capacity might take years, cost billions, and eventually will not provide security, as the threat of repeated attacks remains, putting the whole system at risk. Currently, there is simply no air defence system that can repel a simultaneous attack of 20-30 missiles and drones on a power plant (NV, 2024) When it comes to the state-owned hydroelectric power stations, the war has again underlined the risks associated with these massive infrastructural projects. While their construction has many benefits (discussed in Chapter 2), a major concern today relates to the safety dimension. The dams of the Dnipro Cascade hold millions of tonnes of water, which, if destroyed, can free this devastating mass of water, flooding hundreds of hectares of land and inflicting various humanitarian, ecological and economic damages, as exemplified by the Kakhovka dam destruction in June 2023.

In addition, Ukraine's dams account for about 6% of the total energy produced, which is rather small in comparison to other power generation sources. Predictions of reduced water flow and prolonged droughts in the Dnipro basin due to climate change (Ekodia, 2021) will further challenge the future of hydropower. Building new dams or rebuilding destroyed ones, therefore, wouldn't solve the problem of the centralisation and vulnerability of the energy system, would come at a higher price compared to other much cheaper renewable energy sources, and would pose new challenges to the energy system in the coming years due to the negative impacts of climate change.

To some extent, Ukrainian energy now exists thanks to the three undamaged nuclear power plants. Russian terrorists have not yet resorted to bombing nuclear reactor plants, although we cannot exclude that possibility. The ongoing russian occupation of the Zaporizhzhia NPP remains particularly distressing, as a potential nuclear disaster could bring an insurmountable toll both on the health of the population, the environment, and the socio-economic situation in general. The Chornobyl disaster demonstrated what the scale of such destruction could look like.

At the same time, Ukraine's dependence on nuclear power is not diminishing, and this raises many questions - about geopolitical dependencies related to nuclear fuel and waste, about safety, about costs, and about cheaper alternatives. Even before the war, global trends indicated that investment in a unit of nuclear capacity was the most expensive among other sources. According to the conservative estimates of the International Energy Agency (IEA), investing in a unit of nuclear power before 2021 incurred costs eight times higher than solar power, four times more than onshore wind generators, and over two times more than offshore wind energy (IEA, 2022). With the added risks to the industry from the Russian invasion of Ukraine and supply chain disruptions caused by the war, investing in nuclear energy after February 2022 becomes even more expensive and impractical.

In terms of cost and expediency, a 2014 academic study looked at 180 nuclear power projects around the world and found that 175 of them had exceeded their original budgets by an average of 117% by the time they were completed and took an average of 64% longer than planned (Sovacool et al., 2014). This research doesn't even include the late developments with bankruptcies in the nuclear sector (Guardian, 2017), with record-breaking delays and budget overruns leading to abandoned nu-

clear projects or cases like Plant Vogtle, where two new reactors were built at a cost of $35 billion dollars - the most expensive NPP in history (Georgia Recorder, 2023).

Nuclear power plant construction has historically been challenged by problems of high cost, cost escalation, and construction delays. This has had a disastrous impact on the economy, and the costs for new nuclear power plants keep rising. Nuclear power, therefore, cannot be the solution. There is no time, no excess money to waste, and the risk of yet more nuclear disasters is not worth it.

Moreover, the impact of climate change on nuclear and fossil fuel energy production will only make things more difficult, unpredictable and expensive. Producing 1kW of electricity emits about 3kW of heat, which must be wasted in the flowing water. With climate change, periods of increased temperatures in the river and low water levels will become more common. Unplanned shutdowns of nuclear reactors because of these conditions are already occurring more frequently in France, raising questions about the reliability of these technologies in the context of rising global temperatures and extreme droughts (Cour des comptes, 2023).

Our visions and strategies

The main question is: What do we do next? How long will it take to repair the damage, but before that, what should be rebuilt as it was before, and what should be fundamentally redefined, redesigned and done in a completely new way? The war has put Ukraine in a situation where there is an urgent need to make important decisions about the future of the energy system, because energy is not only an important resource, it is a matter of life and death. While the issues of climate change and energy transition have been pushed aside by the urgency of the war, a certain set of strategies and principles seem to address all these issues at once. These are decentralisation, transition to renewables, democratisation, diversification of solutions, and prioritisation of energy saving and efficiency. These strategic directions will naturally impact the way we interact with the Dnipro River - in terms of water supply, water pollution, mitigation and adaptation to climate change, and wider environmental challenges.

Figure 4. Wind farm in Uraine, illustrative photo
Author: unknown; Source: DTEK

4.4.1. Decentralisation

The constant attacks on Ukraine's energy infrastructure have led many communities to look for temporary, local solutions to provide heat and power to their residents. Small diesel generators have been installed near hospitals or critical facilities to ensure access to electricity in the event of a blackout, new local gas boilers have been built, and existing boilers for industrial use have been connected to the district heating network. Wood and coal stoves appeared in many public or social buildings, such as schools and kindergartens. But energy decentralisation is more than a temporary, wartime solution.

Decentralisation provides a response to the high reliance on huge energy facilities, but it also opens a window for the transition towards more sustainable energy sources. Unlike the thermal power plants that Russia is attacking, wind turbines can be widely placed, making them an unattractive target. Solar rooftops or power plants may be damaged, but a missile or drone could not destroy more than 100 kW of capacity at a time. The Trypilska TPP, on the other hand, was destroyed in one attack, immediately taking 1.8 GW capacity off the grid.

In fact, Ukraine has already become the first country to have a large wind farm built in a war zone. That is Tyligulska Wind Power Plant (WPP), which lies just 100 km from the frontline in the Southern region of Mykolaiv, and already contributes to the energy independence of the region. The plant's 19 turbines have an installed capacity of 114 MW, generating up to 390 MWh - enough to power 200,000 households a year (DTEK, 2023).

The concept of decentralisation presents compelling arguments in terms of resilience, environment and climate change, community empowerment, efficiency, technological innovation, energy security, and energy independence. They apply in times of war as well as peace.

Decentralisation enhances the system's resilience by reducing reliance on centralised power plants, making it less susceptible to disruptions caused by deliberate attacks, technical failures, or natural disasters. Localised energy generation ensures that if one area experiences a problem, it won't necessarily afect the entire grid. Decentralisation provides signifcant environmental benefts. Ukraine has signifcant solar and wind energy potential. Harnessing this will reduce the country's carbon footprint and help mitigate climate change. Reducing thermal pollution of rivers from power plant cooling will make river ecosystems healthier and more resilient to climate change.

Decentralisation empowers local communities by giving them more control over their energy production, fostering economic development and self-reliance.

Decentralisation means efficiency. Localised generation minimises energy loss during transmission, particularly in rural areas, leading to a more efficient distribution of power. Smaller-scale renewable energy installations can be situated closer to where the energy is needed, further reducing transmission losses.

Decentralisation encourages the adoption of innovative technologies, such as smart grids and energy storage systems, driving progress and efficiency.

"Restoring traditional energy generation on previous scales is neither possible nor practical. Either we change our energy development strategy right now or we lose the war" — Ihor Tynnyi (in Economichna Pravda, 2024)

Decentralisation is energy security. Diversification of energy sources decreases vulnerability to geopolitical tensions and market fluctuations, ensuring a more stable supply.

It also means energy independence. Investing in domestic renewable sources reduces dependence on imported fossil fuels, enhancing national sovereignty and security.

4.4.2. Transition to renewable energy sources

The concept of the irreplaceability of base load capacities of traditional sources like coal, nuclear or gas has undergone a radical transformation in recent years. Cost-effective, proven technologies of solar, wind and storage are becoming more efficient every year and can speed the transition to a carbon-free green economy for Ukraine. According to the IPCC, solar technology has become cheaper, with electricity produced from the sun falling by 85% and from wind by 55% per megawatt-hour in the decade to 2019 alone (IPCC 6AR, 2022). And by 2024, average battery costs have fallen by 90% since 2010 due to advances in battery chemistry and manufacturing (IEA Batteries, 2024).

As a result of these global trends, in 2023, the amount of nuclear energy connected to the global electricity grid declined by 1.7 GW (the equivalent of two large reactors). In comparison, additional renewable energy capacity connected to the grid was 507 GW – an increase of 50% in one year. In 2023, nuclear power plants generated 9.2% of global electricity. Renewables generated 30.2%. The IEA, which has for decades underestimated the role of renewables, now predicts that by 2028, RES will generate 42% of global electricity (IEA, 2023). There is no doubt that the future for energy globally will and must be renewable if the world is to avoid the worst scenarios of climate change and exceed 1.5 degrees. This transition to 100% RES needs to happen as quickly as possible.

In Ukraine, the vulnerability of centralised energy sources and the advancements in renewable technologies have motivated the government to set ambitious goals for a large-scale rapid increase of RES in the energy mix. Plans have been declared to reach 525 TWh of annual production by 2050, over four times more than the current production from all sources. This should happen with a new 80 GW of solar and 139 GW of wind capacity, with over 68 GW of green hydrogen production facilities and with 2.4 GW of hydroelectric and pumped storage hydroelectric plants (CMS, 2024).

Various estimates clearly show that Ukraine has the potential to meet its ambitions for more renewable energy. In April 2024, a new study conducted by the Institute for Sustainable Futures at the University of Technology Sydney on behalf of Greenpeace concluded that Ukraine has the potential for solar and wind energy, which exceeds the current demand for electricity (125 TWh/year) almost 150 times. Only 1% of the sustainably usable, geologically suitable land areas within a maximum of 10 kilometres from the nearest high-voltage power line are capable of fully meeting all of Ukraine's demand for electricity (Greenpeace, 2024). According to the same study, Ukraine not only has the capacity to fulfil its internal energy needs but also to generate surplus energy for export to neighbouring countries. Furthermore, the World Bank's estimates indicate that the Black Sea holds significant potential for offshore wind energy production, reaching 251 GW (World Bank, 2020).

Climate change will only increase the water crisis, but clean energy can help. Nearly two-thirds of the world's population experience severe water scarcity for at least one month each year, and climate change will make water flows more erratic. In the Net Zero Emissions by 2050 Scenario (NZE), water withdrawals by the energy sector decline by almost 20 bcm by 2030. The biggest reductions happen in the power sector, where withdrawals fall nearly 15% as coal-fired power generation is quickly replaced by solar PV and wind. Greater energy efficiency also plays an important role in reducing the volume of water needed to meet global energy demand (IEA, 2021).

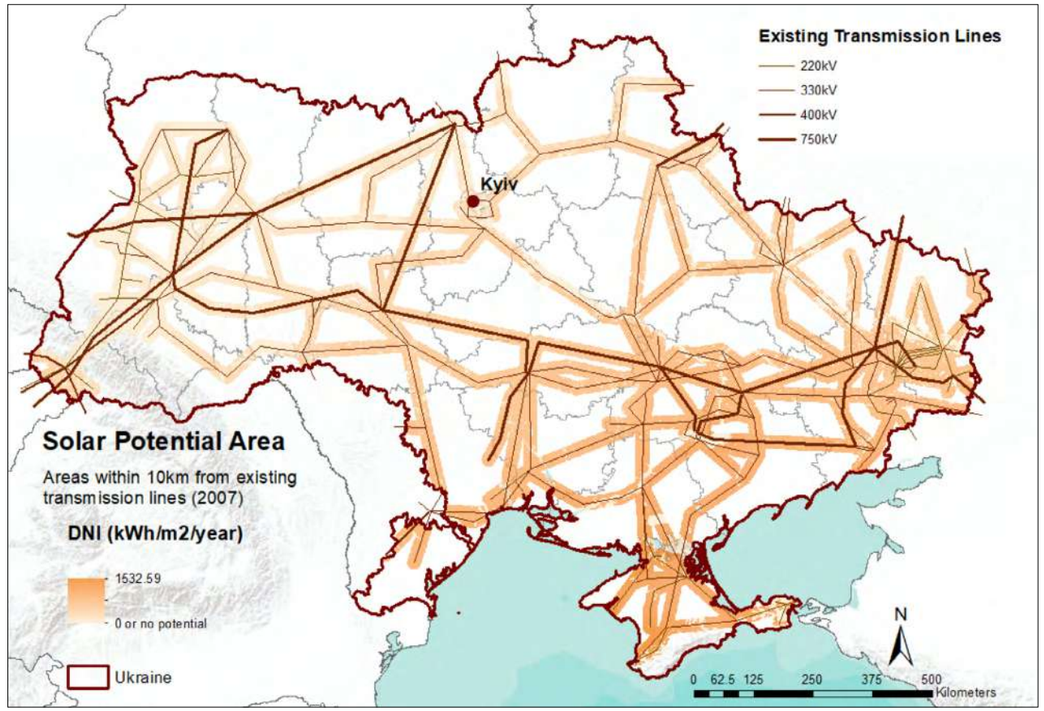


Figure 5. Map of solar potential in the Ukraine – Restriction based on proximity to electricity transmission lines. Author/Source: Greenpeace (2024) *Ukraine: Mapping the opportunitities. Solar and Wind Energy Assesment*.

Renewables can solve the energy sector's water problem.

An integrated approach to energy and water management can help reduce risks across the board. Many of the clean technologies that are being deployed to provide electricity worldwide can also be used to provide access to water. For example, water pumps powered by decentralised solar PV can replace more expensive diesel pumps, and mini-grids can power filtration technologies, such as reverse osmosis systems, to produce clean drinking water. A shift from fossil fuels to renewables in the power sector can lower energy's water needs (IEA, Water crisis, 2023). Together with that, it is now common practice for large wastewater treatment plants in Europe to produce biogas from urban wastewater. Such plants fully cover their energy needs and even produce surplus biogas, which they convert into electricity or feed directly into the gas grid. A study of such water treatment plants in Poland shows that 1 m3 of sludge produces between 13 and 21 m3 of biogas (Masłoń, 2019). For comparison, just 1 m3 of methane can replace 2.1 kg of wood, 1 litre of oil, 1.15 litres of petrol or 1.3 kg of coal (Zagorskis et al., 2023).

4.4.3. Democratisation

The concept of energy decentralisation, together with the major advances in RES technologies, is already significantly democratising the energy sector both globally and in Ukraine. Energy democratisation empowers local communities by giving them more control over their energy production and consumption. This leads to economic benefits through job creation, local investment and revenue generation from energy sales.

Of all the renewable energy sources, solar energy is often seen as the most in line with the principle of energy democratisation. The two main reasons for this are its flexibility in terms of scalability and ownership. Solar energy systems can be deployed at different scales, from individual homes with a few solar panels on the rooftop to large utility-scale solar farms. Whatever the site and size, the technology unit (solar panel, inverter, etc) remains the same. This scalability allows for widespread adoption and empowers individuals and communities to easily take control of their energy production. Solar energy systems can be owned and controlled by individuals, communities, cooperatives, or local governments. This ownership model democratises energy production by giving stakeholders a direct stake in the energy system and its benefits.

Energy communities

Energy communities are one of the symbols of democratisation in the energy sector. An energy community (or cooperative) is a collective initiative where individuals, households, small and medium-sized businesses, organisations and municipalities come together to produce, consume and manage energy together at a local level while significantly reducing environmental impacts. Energy communities are emerging as a key element in achieving the EU's energy transition goals. According to the European Commission (EC, 2022), half of Europe's citizens could produce half of the EU's renewable energy by 2050. In 2023, there are 9525 energy communities in the EU (OBCT, 2023). REScoop – the largest European network of energy communities includes over 2250 cooperatives and their 1.5 million citizens (REScoop, 2024).

The concept of an energy community is not alien to Ukraine. Actually, the story of the first one – "SolarCity" (Solar Town) in Slavutych is quite inspiring. Slavutych is an archaic name for the Dnipro River. The small town in northern Ukraine is the youngest city in the country and the last to be built during the Soviet era. It was founded in 1986 in response to the housing crisis caused by the Chornobyl disaster. Its first inhabitants were refugees fleeing the contaminated areas, mostly nuclear power plant workers and their families.

But in this town, born out of the aftermath of a nuclear disaster, a pioneering energy cooperative emerged with a vision to demonstrate the viability of collective investment in energy infrastructure. After several unsuccessful attempts and legislative challenges, SolarCity was officially registered in 2018. Today, SolarCity operates three solar power plants on buildings in downtown Slavutych, contributing a total of 200 kW of electricity to the grid. The cooperative, which has 200 members, focuses on generating revenue by selling electricity at a green tariff while reducing greenhouse gas emissions by approximately 35 tonnes. In addition, the cooperative allocates 5% of its annual net profit to invest in community projects within Slavutych, improving the amenities for local residents (Energy Transition, 2020).

During the Russian occupation of northern Ukraine, Slavutych faced a severe test of resilience when damaged power lines left the town without electricity. In response, the solar installations were reconfigured to provide immediate power to the community, highlighting their critical role in times of crisis. The lessons are learned. Although the solar installations were able to provide power during the blackouts, heating remained a serious problem for Slavutych during this critical period. Looking to the future, Slavutych aims to become the first town in Ukraine to switch entirely to renewable energy sources.

The local authorities realise that energy efficiency is priority number one, and the daily consumption of electricity and thermal energy has to go down. The municipality is planning to install a mini-CHP (combined heat and power plant) on biomass, which can be used to provide heat and generate electricity for critical infrastructure in the event of a total blackout. With ambitious plans for expansion and infrastructure renovation, the town is on a path to energy self-sufficiency and resilience, demonstrating the transformative potential of solar technologies and decentralised energy initiatives. (Suspilne Chenihiv, 2023).

4.4.4. Diversification of green solutions

The key question for the global green transition is whether renewables can adequately meet the demand for base load capacity, typically provided by centralised nuclear, coal, gas or hydro. While the answer is affirmative, it's important to emphasise that a transition to clean and sustainable energy can only be achieved through a combination of complementary green solutions rather than over-reliance on one or two promising technologies.

A truly resilient modern system would rely on a mix of diversified solutions, policies and strategies. Solar, wind (both onshore and offshore), geothermal, battery storage, heat pump systems, green hydrogen storage. And, of course, energy saving and efficiency measures, circular economy, sustainable mobility and more.

The example of Horenka

A small hospital in the village of Horenka (Bucha district, Kyiv region), rebuilt in a new way by Greenpeace CEE and partner organisations in February 2023, became a good illustration of the importance of diversified solutions. In addition to solar panels on the roof, batteries for energy storage and a ground-to-water heat pump were installed in the hospital. The results reported in February 2024 – after one full year of the new system, speak for themselves: up to 150 days solely on the sun's energy; 55% reduction in annual electricity consumption thanks to the solar panels; 43% reduction in heating consumption thanks to the heat pump, compared to heating with a gas boiler before the renovation. Apart from this, the total energy consumption is 2/3 less, thanks to the energy efficiency measures alone - thermal insulation of the walls and roof and replacement of the windows, all carried out a few years earlier (GP, 2023).

More important than the energy savings, however, was that the hospital continued to accept patients despite the constant power cuts throughout the year and even became a community hub where people could come to charge their phones or warm up with a cup of tea. The mix of green solutions applied at Horenka Hospital clearly demonstrated that the path to energy decentralisation, resilience and effective green transition in Ukraine requires an integrated, multidisciplinary approach and diverse measures.

Figure 6. Photo of the hospital in Horenka being equiped with Solar PV panels on the roof
Source: Greenpeace CEE

i. Solar Energy

As mentioned above, solar technologies are becoming more efficient every year, with costs falling by 85% in the decade from 2010 to 2020 alone. Affordability, scalability and the huge recent improvements are some of the key reasons why solar is at the forefront of the global transition to climate-neutral energy. But these technologies have much more to offer in the coming years in terms of power capacity per unit, life expectancy, recyclability, etc. All this, combined with Ukraine's huge solar potential (Greenpeace, 2024), sets a clear direction for Ukraine. However, central and local governments need to ensure that the coming solar wave takes place in a way that respects biodiversity and nature. Solar energy should only be produced in appropriate places - rooftops, urban areas, degraded terrains and other suitable areas.

ii. Wind Energy

While more expensive than solar, the costs for investment in wind energy have also significantly decreased in the decade from 2010 to 2020 by as much as 55% (IPCC 6AR, 2022). It's crucial that wind power development aligns with solar expansion in the energy mix and spans diverse regions of the country. Only through this approach can a balance between these two sources be ensured, significantly reducing the need for traditional coal, gas or nuclear baseload capacity. Implementing special insurance mechanisms in times of war would encourage foreign and national investments in wind energy, particularly in regions where the energy infrastructure is still under attack and rapid rethinking of the energy system is required.

iii. Battery Storage

Over the same decade, the cost of battery storage technologies has also fallen significantly, by 85% between 2010 and 2020. By 2024, the costs will already be 90% lower (IEA Batteries, 2024). The case of the Horenka Hospital clearly shows the benefits of these technologies, even on a very small scale. The batteries installed there now store the excess energy and allow it to be used hours after the sun has set. This greatly increases the efficiency of a solar system. On a large scale, local battery storage distributed throughout the country will play an important role in balancing the system based on diversified and decentralised renewable energy sources. So far, the Ukrainian government plans to add 0.5 GW of grid-scale lithium-ion battery storage capacity by 2027 (UA Plan, 2024), which is rather low compared to the country's real technological and economic potential.

iv. Green hydrogen

Another smart way to store renewable energy is in green hydrogen. It is well known that renewable energy production is variable, depending on the fluctuating intensity of the sun, wind or other renewable sources. Large-scale deployment of such sources will therefore inevitably lead to energy surpluses, depending on the season or daily weather patterns. However, Ukraine's industrial profile offers excellent opportunities to use these surpluses efficiently. When demand is low, excess electricity could be converted to hydrogen by electrolysis, which could then be used in combustion processes in metallurgy and other industries, gradually replacing coal and natural gas as traditional fuels. Given that Ukraine's industry accounts for the largest share of total final energy consumption (32%), much *[iv. Green hydrogen continued]* of it in the form of coal for combustion processes, an integrated strategy to electrify certain processes and transition to green hydrogen and e-fuels would have a huge impact on the country's modernisation and decarbonisation (IEA, 2021). Estimations show that the country's potential for creating renewable energy hydrogen generators reaches 770.7 GW, and the total potential annual production of green hydrogen is 44.96 million tonnes (Emerging Europe, 2024).

v. Heat pump

Again, as the Horenka example shows, another key green solution for a rapid and thorough transition to a resilient energy system is the heat pump. Heat pump technologies, whether small-scale or for district heating use, are revolutionising the way we heat and cool our homes. They extract latent heat from the ground, air, water reservoirs, waste heat, or even from the sea. They then concentrate this heat using compressors, making it usable and delivering it as heated air or water to buildings and dwellings. Unlike traditional systems, heat pumps do not create heat. Instead, they concentrate and transport it. This allows them to operate at efficiencies of over 400%, meaning that 1 kWh of input can provide 4 kWh of usable heat output. The coefficient of performance (CoP) can be 5.0 or higher in most advanced cases.

vi. Smart hydronic district heating

With their legacy of central heating systems, Ukrainian cities are actually well placed to move to smarter hydronic district heating based on heat pumps or other technologies based on heat recovery. Modern and fairly efficient solutions are already common in developed cities. Sources for direct heat recovery could include industrial boilers, foundries, steel plants, aluminium smelters or even light industry facilities like food factories and large bakeries. Highly efficient residual heat sources for heat pump conversion can include wastewater treatment plants, sewage networks, light industry, even subways, data centres, supermarkets, refrigerated warehouses, car parks and more (Van de Vyver et al., 2020).

vii. Innovation

Of course, not all solutions can be listed in this chapter. Smart grids, improved interconnections with other countries, circular economy and sustainable mobility strategies, deep and lasting energy behaviour change initiatives - all these and many more combined should also play an important role in the mix of solutions to reduce the need for centralised base load capacity while mitigating climate change and anthropogenic pressures on Ukraine's environment and river systems.

4.4.5. Energy saving and efficiency

Any debate about the future of energy should begin with the observation that the cleanest, safest and greenest energy is the one that was never produced. So the key question, above all else, is how to increase efficiency and save energy. While the realities of war are putting very significant pressure on Ukraine's energy sector, a well-executed reconstruction vision also has the potential to respond to these core issues.

Before the invasion, Ukraine ranked 18th globally in energy intensity, meaning it needed much more energy to produce one unit of its GDP than other countries (IEA, 2021). That is an obvious challenge for the country's future development and competitiveness, as well as a factor for its energy resilience in times of war. According to the IEA, the main contributors are industry (32%), residential sector (28%), transport (19%), and commercial/public services (10%).

The industrial sector

Although the industry sector is not the main focus of this integrated vision, it is important to note that Ukraine definitely needs a thorough analysis of the industry's potential to reduce its energy intensity and carbon footprint. Particular attention should be paid to the possibilities for residual heat recovery from combustion processes, as well as the potential for reuse and reduction of water use in industrial processes. Extractive industries, for example, can help by reducing their water needs and using better treatment technologies (IEA, Industries, 2022). Measures to save water and use it more efficiently also reduce energy demand. Smart water reuse and recycling can reduce the need for treatment and the associated energy consumption. Energy and water stewardship should, therefore, go hand in hand (IEA, 2024).

The residential sector, commercial and public services

The potential for the residential sector, together with commercial and public services, to reduce their energy needs and improve Ukraine's energy intensity profile remains huge. Decades of reliance on cheap fuels and lax environmental standards have left Ukraine with persistent energy inefficiencies. These historical factors still impact the country's energy landscape today. Heat is distributed through poorly maintained systems to users without proper meters or control mechanisms. Most Ukrainian homes and public buildings have poor thermal insulation and old windows. To address this, the focus should be on optimising thermal efficiency in buildings. Ideally, that has to go with electrification of combustion heating, with measures for replacing the old fossil fuel boilers with efficient electric heat pumps or with efficient new-generation district heating.

As noted in the Ukraine Plan 2024-2027, space heating accounts for up to 60% of total building energy consumption. The dependence of building heating systems on natural gas, which accounts for more than 70%, remains critical. Improving the energy efficiency of residential buildings can easily reduce their energy consumption by more than 40-50% (Ukraine Plan, 2024). However, it is arguable that heating accounts for a larger share, reaching up to 85% of total energy consumption in buildings. Savings could, therefore, be in the range of 40-70% (Ukraine plan, 2024).

Again, the case of the small outpatient clinic in the village of Horenka illustrates this in practice. During its renovation in 2018, the walls and roof were insulated, and the old windows were replaced. The result was significant. From a gas consumption of 22500 m3 per year before the renovation, the demand dropped to 7500 m3 for the years until 2023. Or three times. After the refurbishment in 2023, when the old gas boiler was replaced by a heat pump and solar panels, and battery storage was installed, energy costs fell even further.

Efficiency improvements at the building level can compete with advances in heat production from new technologies. To effectively reduce demand for district heating, regulations and tariffs need to incentivise energy-efficient consumption. Billing based on the true cost of providing heat encourages better efficiency. Educating heat users about consumption and costs is essential. Energy efficiency education and incentives for improvement projects, from small weatherstripping measures to intelligent heating, ventilation and air conditioning controls, are a worthwhile investment.

4.4.6. Energy modelling

To illustrate the real impact of energy efficiency and smart energy solutions in residential and public buildings, several future energy scenarios were tested on a small neighbourhood in Kremenchuk using advanced predictive energy modelling tools. The study was carried out for the purposes of the Dnipro River Integrated Vision and is discussed in detail in section *6.9.* The models simulated possible modernisation strategies using different technologies available at the time of this report.

The Standard retrofit scenario, derived from the analysis of the 35 residential buildings in the neighbourhood, shows that a typical multi-family apartment building built before 1991 has the potential to reduce its energy consumption by 58% if improvements are made in terms of airtightness of the building with new envelope retrofit; new wall, roof, and floor insulation to reduce heat transfer with external climate; new windows properly sealed and insulated to prevent heat transfer through the glass and frame; gas combi boiler updated to reduce energy losses by 30% (0.95 CoP) at district heating plant; LED lighting replacing old incandescent bulbs to reduce electricity consumption.

The Advanced retrofit scenario goes even further by offering a considerable shift in space heating load thanks to improved efficiency of the heating system, where the Gas Combi Boiler has been swapped out for high-efficiency district heating air to the water heat pump (3.5 CoP), which runs on electricity. That will further reduce the building's overall energy consumption by up to 82%. In ideal conditions, 1/3 of the energy for all 35 residential buildings in the neighbourhood could be produced locally by solar panels installed on the roofs.

To demonstrate the importance of rapid improvement in the energy profile of Ukraine's social infrastructure, our study goes further and provides predictive energy modelling for a kindergarten, secondary school and hospital in Kremenchuk. Retrofitting, including an improved heating system, reduces the total energy consumption by up to 75% in the kindergarten, 77% in the school and 81% in the hospital. The Advanced Retrofit scenario, which includes state-of-the-art heating technologies (high-efficiency heat pump for district heating) together with solar panels, covering 75% of the roof surface, turns the kindergarten and the school into Positive Energy Buildings, with an energy surplus of 8% and 25% respectively. These high values are in part due to the seasonal occupation of these facilities.

With an advanced retrofit combined with advanced chillers for modern hospital heating, ventilation, and air conditioning systems (CoP 6) and 75% of the roof covered with PV panels, potential savings of up to 90% can be achieved compared to current operating energy. However, summer cooling loads make it difficult to achieve positive energy in hospital buildings with additional renewables.

What does all that mean for the whole country and for the vast area of the Dnipro basin?

In 2022, the municipality of Kremenchuk was running 45 kindergartens, 32 schools and 11 hospitals. Their electricity consumption in that year was 0.36 GWh, 0.66 GWh and 3.43 GWh, respectively. This makes a total of 4.45 GWh. In general, Ukraine, on the other hand, operated 9,300 kindergartens, 12,926 schools and 1,186 hospitals at that time (Ukrainska Pravda, 2023; PON, 2023; Word & Action, 2021). If we average the values and assume that each kindergarten, school and hospital in Ukraine consumes a similar amount of energy as their typical counterparts in Kremenchuk, we can speculate that:

- *a*ll kindergartens in Ukraine consume a total of 75 GWh of electricity per year;
- *a*ll schools in Ukraine consume a total of 265 GWh of electricity per year;
- *a*ll hospitals in Ukraine consume a total of 370 GWh of electricity per year;
- *a*ll three types combined consume a total of 710 GWh of electricity per year.

To put these 710 GWh into perspective, this is exactly half of the annual energy production of the Kakhovka HPP, which was 1420 GWh before it was destroyed on 6 June 2023 (357 MW capacity, 1420 GWh annual production). From another perspective, 710 GWh is about ⅛ of the electricity produced in one year by one nuclear reactor at the Zaporizhzhia NPP (950 MW capacity, 6300 GWh annual production per reactor).

However, these figures only cover electricity consumption, not heat. According to the information delivered by the municipality, all of the above social facilities in Kremenchuk consumed exactly 40,934,629 Gcal of heat energy, usually supplied by district heating. If we convert that heat from Giga calories to gigawatt-hours, we find that all these buildings use more than ten times more energy for heating than for electricity. For Kremenchuk alone, the figures show that all kindergartens, schools and hospitals together consumed 40 GWh of heat in 2022. Extrapolated to the whole country using the same methodology, the figures are 9015 GWh of heat. Considering that our energy modelling showed how the school and kindergarten could be transformed into not only energy-neutral but positive energy buildings, the message is clear: improving the energy efficiency of the country's social infrastructure alone would have

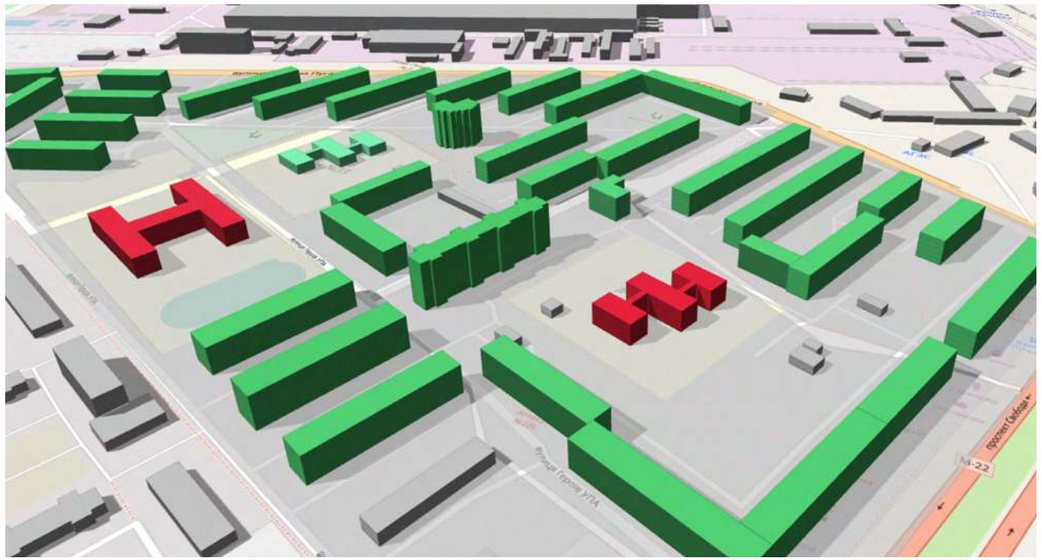


Figure 7. The neighbourhood in Kremenchuk and its 35 residential buildings included in the Energy modelling.
Author: Elaborated by Ro3kvit and Greenpeace CEE

a significant impact on overall electricity demand and production, and would dramatically change the perception of the importance and irreplaceability of old, centralised energy sources.

What about the solar potential of all the kindergartens, schools and hospitals?

It is interesting to look at all those buildings as potential areas for solar energy production. The total roof area of all the kindergartens, schools and hospitals in Kremenchuk is approximately 130,000 m2. Needless to say, not all of this surface could be used for the installation of solar panels due to shading or construction constraints. But if only ⅓ of this area is covered with 450W solar panels, this would give a total peak capacity of 10 MW or an annual electricity production of nearly 14 GWh. More than three times the electricity currently consumed by all these facilities in the city.

Extrapolated to the whole country, the numbers are staggering. If we average the surface area of the kindergartens, schools and hospitals in Kremenchuk and extrapolate these to their counterparts in the whole country, we can assume that all the roofs of these buildings in Ukraine cover about 35 million square metres or 35 km2. If ⅓ of this area is covered with solar panels, this would provide a total peak capacity of over 2600 MW and an annual electricity production of 3700 GWh. This is more than half of the annual solar energy production in Ukraine before the war (6600 GWh), or more than half of the energy produced by a nuclear reactor (6300 GWh), just by solarising all kindergartens, schools and hospitals in the country.

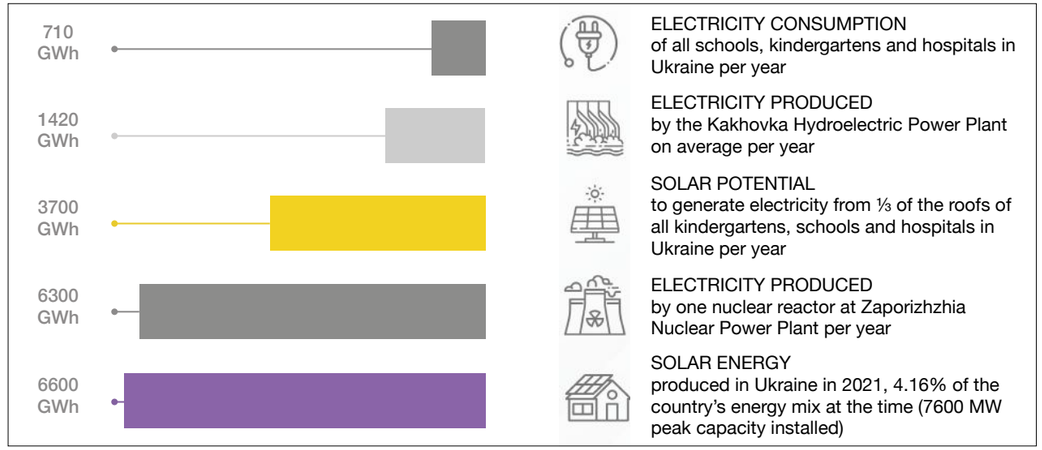


Figure 8. Comparative visualisation of provisional electrical and heat energy consumption, actual energy production by different sources, and solar energy production potential. In GWh on a yearly basis.

Conclusions

If we apply the results of our modelling of the residential and social buildings in Kremenchuk to the nearly 180,000 residential buildings and more than 70,000 public buildings currently existing in Ukraine (Ukraine plan, 2024), most of which are very aged, we can conclude that improved building efficiency + next generation heating + local solar power production would have a huge impact on Ukraine's energy profile. This is the direction for radical change towards sustainability, resilience, decentralisation, democratisation and energy independence that Ukraine needs right now.

All of the measures described in this chapter will have a profound impact on Ukraine's development. Energy decentralisation and democratisation will make the system far more resilient and independent in times of war, as well as more competitive and adaptable in times of recovery and peace. A greater share of solar and wind energy in the mix, together with the diversified and smart application of various green solutions, will redefine the need for centralised base load capacity, otherwise provided by dangerous or polluting sources such as nuclear, coal or gas. All this, together with well-planned energy efficiency measures in buildings, will significantly reduce the energy intensity of the Ukrainian economy and create millions of green jobs in the long term. This will free up resources to optimise Ukraine's national defence capabilities and post-war economic growth.

Clearly, all of this will have a huge impact on Ukraine's river and marine systems, too. The phase-out of coal and the reduced need for gas-fired heat and electricity will bring Ukraine closer to carbon neutrality and contribute to the global efforts to mitigate climate change. Reduced need for cooling in nuclear or fossil fuel power generation will ultimately lead to reduced thermal pressure on river systems, significantly improving adaptation to water stress, decreased runoff and other impending impacts of climate change. Efficient and optimised energy and water use in Ukraine will also provide direct answers to the question of whether war-damaged dams such as Kakhovka should be rebuilt or whether it is more beneficial to allow natural ecosystems to recover. The huge investments usually required for such hydropower projects will instead be redirected to more resilient, decentralised and modern energy solutions for Ukraine.

4.5. Modernised agriculture

Introduction

In the last decade, Ukraine was one of the world's largest agricultural producers and exporters. It was known as the breadbasket of Europe. The importance of the sector can be shown in the world ranking position in different sectors and in the GDP. In 2008, agriculture accounted for 8.29% of Ukraine's GDP, and by 2012, it had grown to 10.43%. Agriculture added $13.98 billion of value to Ukraine's economy in 2012. Ukraine is the world's largest producer of sunflower oil, a major global producer of grain and sugar, and a future global player in meat and dairy markets. It is one of the largest producers of nuts. Ukraine used to produce more natural honey than any other European country and is one of the world's largest honey producers. Because Ukraine possesses 30% of the world's richest black soil, its agricultural industry has a huge potential.

In 2014, Ukraine's total grain crop was estimated to be 64 million metric tons. In 2014, Ukraine lost *de facto* control over portions of several regions due to the war in Donbas and the annexation of Crimea by russia. Hence, the actual available crop yield was closer to 60.5 million metric tons. Due to the decline of the metallurgy industry, Ukraine's prior top export category, as a result of the war in Donbas, agricultural products accounted for Ukraine's largest export category (FAOSTAT, 2023). Farmland was the only major asset in Ukraine that had not been privatised for a long time after communism. In March 2020, Ukraine's parliament lifted a ban on the sale of farmland. The land market was fully opened for the first time independence on 1 July 2021 (Verkhovna Rada of Ukraine, 2020).

The Russian aggression in Ukraine has brought a significant toll on agricIture. Due to occupation, safety and security, land mines and war-related pollution, large parts of the land can not be used. The russian war crimes on the Azov Sea impacted the safety of transport routes for grain and other export products drastically. Also, insufficient and insecure water supply plays a role in keeping the agriculture industry going due to the damages made to the dams. Unfortunately, the exact numbers of decrease in agriculture in 2022 and 2023 are not available.

Agriculture is the second largest water user (after industry) in the Dnipro River Basin, withdrawing 2,515 million m³, or 38.5% of the total water in the basin. It is important to note that about 80% of this volume is abstracted from the Lower Dnipro sub-basin - 2052 million m³. This is currently not possible due to the occupation of the territories, active hostilities and the destruction of the Kakhovka dam and reservoir. In agriculture, water resources are used primarily to meet the irrigation needs of the agricultural sector - 86%, which is about 2,163 million m³.

Agricultural water users in the Dnipro basin are mainly agricultural producers, mainly concentrated in the Lower Dnipro sub-basin - Kherson, Zaporizhzhia and Mykolaiv regions. 97% (2,446.6 million m³) of the agricultural needs in the Dnipro basin are met from surface water bodies, and only 3% from groundwater (68.4 million m³), which means that the Dnipro River plays a critical role in this sector. Ukraine's irrigation sector is facing an unprecedented challenge. After years of disinvestment in irrigation, drainage and associated hydraulic infrastructure, the need for investment in infrastructure rehabilitation, modernization and management is becoming ever more pressing. Much of the public irrigation and drainage infrastructure was designed and constructed during Soviet times when irrigated agricultural production was centrally planned, water resources were plentiful, and the cost of pumping electricity was not an issue. The situation has changed radically, and systems are not properly adapted to the needs of the irrigated agricultural sector in Ukraine today (World Bank, 2017). Below we suggest some approaches and strategies aimed at modernising the agricultural sector and decreasing the burden of agricultural activities on the Dnipro River, addressing both the issue of water scarcity and water pollution.

4.5.1. Drip irrigation

The problem is to raise the water from the Dnipro's natural channel to a height of about 10 metres to the height of the existing canals and water pipes (Kakhovka, North Crimean). It is necessary to develop modern pumping systems, possibly a network of small hydraulic structures (ponds), etc. In modern canals, water losses accounted for 10-40% of water consumption in agriculture. This led to waterlogging and secondary soil salinisation. Modern irrigation technologies (drip irrigation) require less water and allow for the development of intensive farming (vegetable growing, horticulture), which is more profitable than growing grain crops.

In the context of increasingly threatened water scarcity and the need to increase agricultural productivity, the transition to drip irrigation is considered an important, if not necessary, step. Drip irrigation, based on the precise and targeted delivery of water to plant roots, offers significant advantages over traditional irrigation methods.

The transition to drip irrigation has already demonstrated impressive results around the world. For example, in Israel, where water resources are extremely limited, drip irrigation has reduced water consumption in agriculture by 40-60% and increased yields by up to 30%. In Spain and Italy, the use of drip irrigation has also saved significant amounts of water and increased field productivity by 20-40%. Global practice also confirms the effectiveness of drip irrigation. For example, in the US, more than 50% of agricultural land in some states is already equipped with drip systems. This has led to a 30-50% reduction in water consumption in agriculture and a 20% increase in yields. The use of drip irrigation in developing countries also yields significant results. For example, in India, where water resources are also limited, the introduction of a drip irrigation system has reduced water consumption by 30-50% and increased food production, ensuring food security for millions of people. Thus, global experience shows that drip irrigation not only effectively reduces water consumption in agriculture but also significantly increases field productivity, making it an important tool for sustainable agricultural development in a changing climate and limited resources.

Ukraine, where agriculture plays a key role in the economy, also has a variety of climatic conditions, from dry steppes to temperate climates in the western regions, which require flexible approaches to irrigation. In addition, the introduction of drip irrigation in Ukraine could help increase the yield of agricultural crops such as cereals, vegetables, and fruit. This would help improve the country's food security and increase the export potential of agricultural products. Given Ukraine's potential in agriculture and the need for efficient use of resources, the introduction of drip irrigation is a relevant and promising area of development that can bring significant benefits to both agricultural enterprises and the country as a whole. Thus, the use of a drip irrigation system will reduce water consumption by 50%, which is approximately 1210 million cubic metres.

Figure 1. Photo of traditional irrigation methods
Author: unknwon; Source: Agro-business.com.ua

Figure 2. Photo of the drip-irrigation technology
Author: unknown; Source: https://ukrhoz.com.ua

4.5.2. Treated wastewater for irrigation

Using treated wastewater to irrigate agricultural fields is an effective and innovative solution that addresses several key water and agricultural issues. This approach offers a double benefit: recycling wastewater and providing an additional source of moisture for irrigating agricultural land. Water scarcity is one of the main problems of the modern world, and agriculture, which consumes a significant amount of water resources, has become one of the largest consumers. At the same time, large quantities of wastewater are released into the environment, which can lead to water pollution and environmental problems. The use of treated wastewater for irrigation of agricultural fields can solve both of these problems: reduce the negative impact on the environment and ensure a sustainable water supply for agriculture.

The effectiveness of using treated wastewater for irrigation of agricultural fields is confirmed by numerous studies and global practice. For example, developed countries such as Israel, Switzerland, the United States and Australia have long been using technologies for the reuse of treated wastewater in agriculture (see Table 13). These examples demonstrate that using treated wastewater to irrigate agricultural fields is a feasible and effective approach, especially in areas where water resources are limited. They also show the importance of proper water quality management and monitoring to ensure the safety and sustainability of such systems.

In addition, the use of treated wastewater for irrigation of agricultural fields can reduce the load on natural water bodies and rivers, which

Table 11: Examples of wastewater treatment for agriculture

Israel is considered a leader in the use of treated wastewater in agriculture. According to the Israeli Ministry of Agriculture, in 2019, about 86% of treated wastewater in Israel was used to irrigate agricultural fields. Treated wastewater is used to irrigate more than 60,000 hectares of agricultural land. This significantly reduces freshwater consumption by more than 50% and ensures a stable water supply in a resource-limited environment.
In Switzerland, the use of treated wastewater for agricultural irrigation has become standard practice. In Switzerland, more than 80% of treated wastewater is used to irrigate agricultural fields and green spaces. The introduction of a system for reusing treated wastewater has reduced freshwater consumption in agriculture by 40%.
In the United States, some local governments and agricultural enterprises have successfully implemented systems for reusing treated wastewater for crop irrigation. For example, in California, the city of Fresno's wastewater recycling programme for irrigation has reduced freshwater consumption for irrigation by 30%. Individual agricultural enterprises use treated wastewater to irrigate about 100,000 acres of land.
In some regions of Australia, which face serious water resource problems, the use of treated wastewater for irrigation of agricultural fields is an effective solution. For example, in the city of Adelaide, a programme to use treated wastewater to irrigate public green spaces has reduced freshwater consumption by 25%. The treated wastewater is used to irrigate more than 30,000 hectares of agricultural land in different regions of the country.

Figure 3. Photo of the Bortnychi Aeration Station operated by "Kyivvodokanal" – wastewater treatement plant in Kyiv
Author: unknown (Public Domain); Source: Kyivvodokanal

Figure 4. Photo of the Shafdan Wastewater Treatment Plant in Israel
Author: unknown; Source: Mekorot, Israel National Water Co.

contributes to the preservation of ecosystems and biodiversity. It also saves additional costs for the construction and maintenance of artificial reservoirs or water supply systems from remote sources.

Despite all the benefits, using treated wastewater to irrigate agricultural fields requires careful monitoring of water quality and adherence to strict safety standards to prevent toxic contamination of soil and plants. However, with the right approach and appropriate technical and technological support, this method of irrigation can be an efficient and environmentally sustainable solution for agriculture in the future. Thus, with a change in approach and appropriate technology, it is possible to reduce water withdrawals from the river by 75%.

Partnership investment example

There is also an example of an effective approach to the interaction between agribusiness and the municipal water utility through a partnership investment project between Mariupolvodokanal and the agricultural holding Harvest, which began in 2021. The essence of the project was that Harvest was willing to purchase water for irrigation after treatment at the biological treatment plant of the water utility. This approach allowed for increased agricultural productivity by purchasing treated water, which is significantly cheaper than using natural sources. For Mariupolvodokanal, this provided an opportunity to avoid discharging treated wastewater into the Sea of Azov and to sell it at a fixed price. This approach is a good illustration of a win-win practice.

The project implementation cost for Mariupolvodokanal was 59 million UAH and included the construction of infrastructure, namely a pumping station and a pipeline with a diameter of 630 mm and a length of several dozen kilometers to the consumer. The expected payback period for the investment was approximately 8 years. It was planned that from March to October, the entire volume of treated wastewater would be used for agribusiness needs. The use of an efficient irrigation system would significantly increase agricultural productivity and make it more resilient to climate fluctuations or changes. The first phase of construction began at the end of 2021; however, unfortunately, it was interrupted due to the onset of military actions and the occupation of the Mariupol area.

4.5.3. Facing further challenges

The above sections offer some possible solutions to the foundational challenges related to the use of water in agriculture. Of course, the agricultural sector is also facing more urgent water related caused by the ongoing russian agnression.

In many areas of the Dnipro River basin and across Ukraine, the Russian army has placed landmines. These landmines can explode, leak, or degrade slowly, negatively impacting the groundwater. At the same time, the use of pesticides, not only in Ukraine but worldwide, needs to be openly discussed and limited to maintain a natural balance. Mitigating those and other issues present a significant challenge to the industry and requires significant efforts from a range of actors. Some of these issues are discussed in more detail throughout the other sections of this report.

Ultimately, from limiting the use of pesticides to the demining of fields, and to the modernisation of water usage techniques, the agricultural sector can benefit from adopting more environmentally friendly approaches. A combination of increasing awareness must be complemented by a supporting policy base and regulations.

4.6. Developed mobility and connectivity

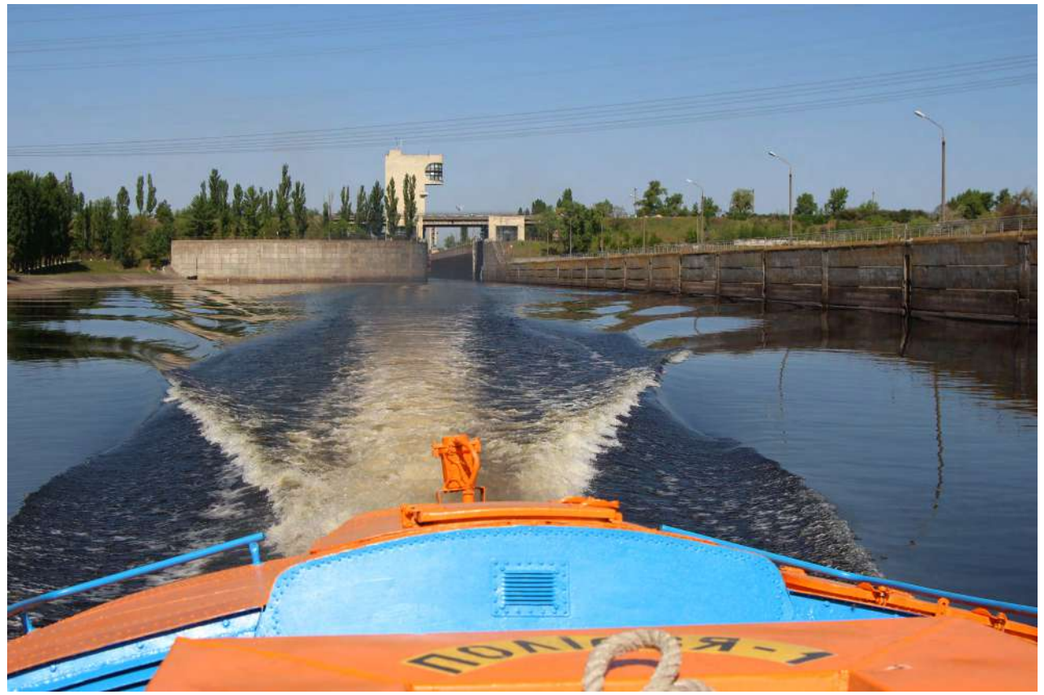


Figure 1. Photo of a passenger boat moving away from the sluice of the Kaniv dam.
Author: Oleksandr Malyon

4.6.1. Reviving water navigation and transportation

Transportation of goods by Water remains the most cost-effective mode in many countries, consistently outperforming both railway and highway transport in terms of cost efficiency. Before the full-scale invasion, there was notable growth in the sector, particularly with the increased grain transportation and other agricultural products. Although the necessity of locks to navigate differences in water levels presents economic considerations, their value remains substantial. Enhancing the natural flow of rivers could potentially streamline transport operations, though it may introduce challenges related to water depth and breadth that must be carefully managed.

In terms of passenger transport, various modalities have been utilized, including regional public transport, local transport with ferries, and recreational boat cruises. However, it is advisable not to prioritize public transport concepts immediately. Instead, focusing on recreational cruises or trips that highlight Ukraine's cultural and heritage aspects — such as "Experience Ukraine on a boat trip" — could prove more immediately beneficial. Additionally, in larger cities, exploring small ferry or water taxi systems could offer a swift and environmentally friendly transport solution.

Table 12: Water navigation and transportation strategies

Comprehensive water transport assessment: It is recommended to initiate comprehensive studies to assess the economic potential of water transport. The focus should be on agricultural products transportation and recreational opportunities along the Dnipro River. These studies should consider current infrastructural constraints like dams and locks, and explore scenarios where fewer locks might be required.
Green operations: Further strategic development should aim to transition freight water transport to "green" operations. As outlined by the Ministry of Reconstruction, this involves not only modernizing locks and upgrading navigation systems but also developing multifunctional port hubs and establishing a green, energy-efficient cargo transport fleet.
Regulatory improvements: The current regulatory framework, characterized by complex bureaucratic procedures, excessive taxation, and unreliable budget funding, severely hampers investment attractiveness and fails to meet ecological standards. New regulations should be drafted based on the outcomes of the aforementioned studies, with a focus on creating a competitive market to attract investment and promote sustainable growth in the sector.

4.6.2. Bridging scenarios, improving connectivity

The divisive impact of the Dnipro River on regional connectivity was discussed in earlier chapters. The orientation of transport and international corridors typically spans from South-North and West-East. Presently, connections to the East are severely disrupted due to the ongoing Russian invasion. As highlighted in Chapter 2, the Ministry of Infrastructure has prioritized infrastructural development and connectivity enhancements in the western regions under these circumstances. This context raises critical questions about potential enhancements to bridge and road networks that could increase connectivity, thereby improving mobility and economic outcomes in the affected regions. The team developed suggestions based on the preliminary study that comprehensively covers the broad mobility picture of the regions along the Dnipro River:

Table 13. Recommendations for mobility strategies in the Dnipro River basin

The bridging scenario on the Regional level. It involves a collaborative approach, where regional and local authorities join forces with mobility experts, guided by the insights from this report, to enhance regional and urban mobility. The realization of this scenario hinges on the complete liberation of Ukrainian territories, setting the stage for comprehensive reconstruction readiness.
Continuation of the modelling for the bridges and infrastructure near Nikopol and Kherson. The preliminary spatial modelling for bridges and infrastructure near Nikopol and Kherson has been advanced by Ro3kvit's mobility team. Initial findings indicate that adding two new bridges impacts the overall road network, enhancing Integration and Connectivity. However, to attain substantial improvements, additional in-depth studies are required.
Continuation of the modelling for the bridges next to Kyiv. Similarly, the modelling associated with bridges near Kyiv has been addressed. As previously noted, Kyiv's bridges frequently experience congestion during peak traffic hours. The simulations regarding the construction of new bridges near Pliuty and Liutizh have demonstrated noticeable enhancements to the overall network. This progression underscores the ongoing need for targeted infrastructure developments to alleviate congestion and foster smoother transportation flows across the Dnipro River.

Figure 2. Map of the Connections along the Dnipro River that will need to be revised and significantly improved.
Author: Elaborated by Ro3kvit and Greenpeace CEE

4.7. Improved accessibility and recreation

Introduction

The identity of Ukraine can be found and felt at the Dnipro River. Both for Ukrainians and international visitors, Ukraine can be experienced and understood through the Dnipro River's history, stories, beauty and complexity. Therefore, we need to make the river accessible, the places along river bank connected, and we should include recreational and educational elements.

For this, the Dnipro river should be public as much as possible, to experience all the strength of it. This might lead to questions of de-privatisation at certain locations, of course within the restrictions of safety and security: next to a basic level of military presence, port activities and natural developments, visitors should be able to experience the river in all its aspects. Municipalities can use urban strategies, masterplans or zoning plans to rethink existing zoning plans.

"To understand Ukraine, you have to see the Dnipro River."

Figure 3. Photo of the Parkovy pedestrian bridge in Kyiv, 2021
Author: Vladysla Lypovyi; Source: Wikipedia.org (CC BY-SA 4.0)

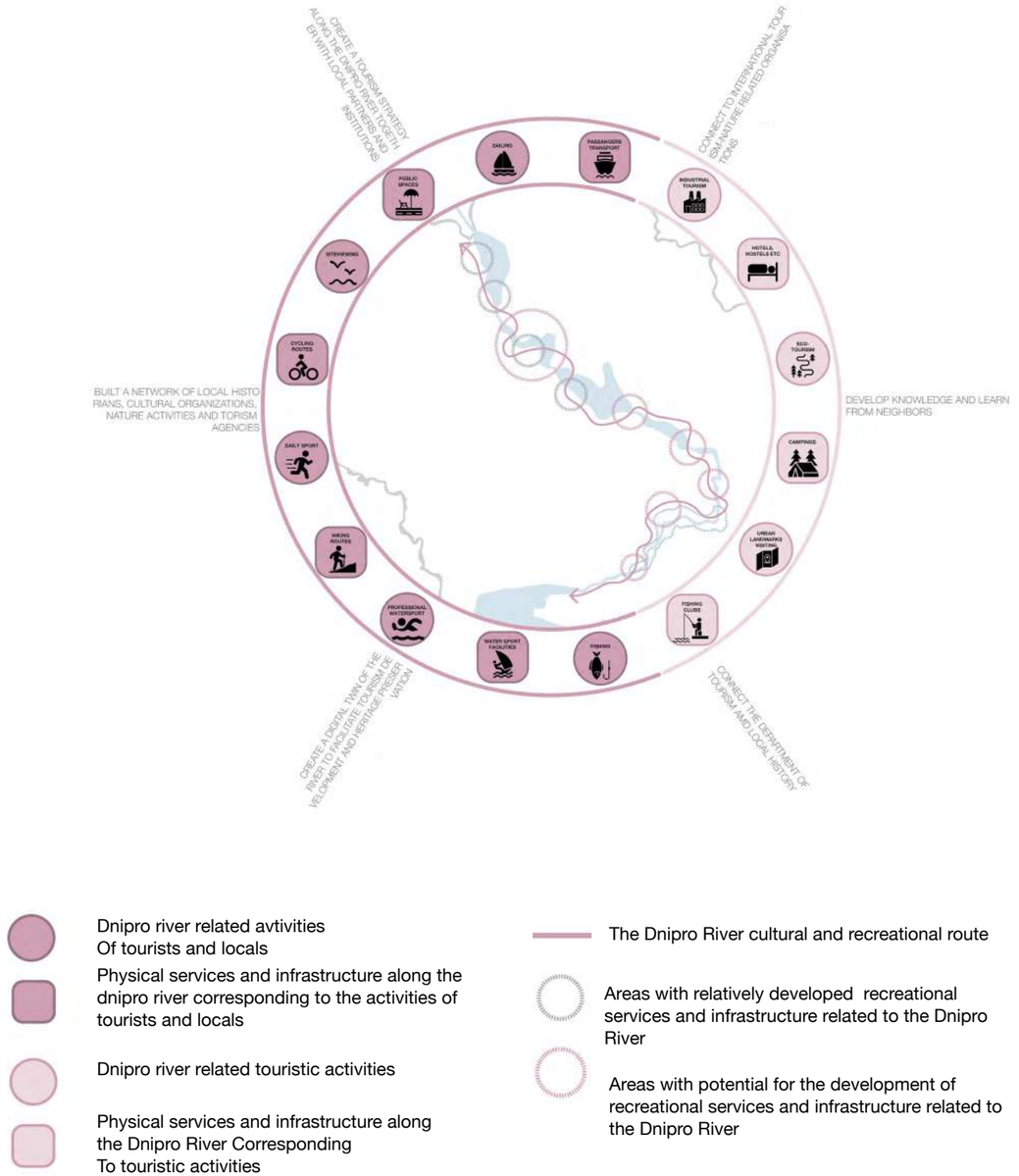


Figure 4. Infographic chart of accessibility and recreation of the Dnipro River
Author: Elaborated by Ro3kvit and Greenpeace CEE

4.7.1. Develop green natural recreational embankment routes

The Dnipro River is a stretched line with pearls of interest. Paths along the line can be used to walk and cycle. Riverboat trips can be restored. The water can be shown via boat trips (day, week, longer) and pearls of recreation.

As mentioned above, at this moment, only fragments of the river embankments are accessible, and definitely not as a stretch. The students who contributed to the Winter course in Lviv at the Kharkiv School of Architecture came up with the idea of developing a path along the full length of the river (walking, cycling) to experience the river in all its beauty. Churches, castles, cities, differences in landscape and villages can be viewed. A long trail can be developed for hiking and cycling, connecting points of interest, places of recreation and points of rest.

Unfortunately, not only beauty will be discovered. The River can also explain the dark times and war crimes in WW2, and recently, Chornobyl and Kakhovka (Chornobyl, Kakhovka) can be explained along the River.

Is it ethical to think about recreation and tourism now? We believe it is. All means are needed to recover after the war ends. Tourism and recreation are also about educating and connecting to the country, the context and the past. Also, it can be expected that many people from abroad and many Ukrainians will want to travel around, discover the country, and discover their own identity. The Dnipro River will be one of the recreational links to this. To prepare Ukraine for a post-war situation to combine learning and relaxing is not inappropriate to us.

Table 14: Types of potential for the development recreational and touristic activities around the Dnipro River

Recreational potential	Beaches, recreational zones, barbecue areas, local acitivies and events
Natural potential	Eco-tourism, topography tourism (experiencing the land from the water), new natural parks, eco-industrial tourism (see Horishni Plavni)
Sports potential	Swimming, running, cycling, diving, sailing, rowing, canoeing, competitive fishing
Cultural potential	Historical and archeological expeditions and guided tours, educational excursions and visit, national folk culture and artisans.
HoReCa potential	Camping, sanatoriums, hostels and hotels near the river, restaurants, cafes, local gastronomy and traditions
Urban potential	Connecting public spaces and public structures to the river and the embankments

4.7.2. Connect the riverside with urban fabrics

The river is crossing the country, and is alongside a large number of oblasts and hromadas. All of them have local activists, historians, specialists and entrepreneurs. We experience, the river bank has a lot of “owners”. It is not our role to decide who would take the lead in connecting these networks. We give recommendations what connections could and should be made to raise awareness of the potential.

Table 15: Strategies for the development recreational and touristic activities around the Dnipro River

Tourism strategy	Create a tourism strategy along the river, with local partners and institutes.
Learning	Develop knowledge for a new tourism industry (hotels, camp sites, agencies), learning from the neighbouring countries like the Baltic states, Romania and Poland.
Community engagement	Build a network of local historians, cultural organisations, nature activists and tourist agencies.
Digitalisation	Create a digital twin of the river, including many layers of history and scales of nature.
Government support	Connect the national department of tourism and other international stakeholders

Interviewing
Dmytro Stiepnov

I am originally from Mariupol, but now I live in Dnipro by the river. I love the sight of it here; it inspires me and reminds me of the sea back home. The first time I saw the Dnipro was when I was 10 years old. I came to the city of Dnipro with my brother for a competition—he is an internationally renowned athlete. While here, I rode the cable car. Our rowing base is now on Monastyrskyi Island, right in the city center, with that cable car that currently isn't working. We plan to repair and relaunch it soon.

At first, when I moved to Dnipro, I missed the sea because the Dnipro River wasn't the same. But a trip to Düsseldorf put things in perspective; the Rhine doesn't compare to the Dnipro. I missed the vast expanses of the Azov Sea. Last year, while driving in Cherkasy across a bridge, I was reminded of the Merefa-Kherson bridge here, which is the longest bridge across Monastyrskyi Island. It was foggy, and I couldn't see the riverbanks.

Looking out the car window, I couldn't see where the river ended, and it felt just like the sea. There's a stretch of the Dnipro where you drive over the dam, and it looks just as endless.

That's when I realized that the Dnipro, in its own way, is as vast as the sea.

For me, the Dnipro is mostly associated with rowing training. In Mariupol, I owned fitness and rowing clubs. After moving to Dnipro, I restored the rowing club. Rowing was popular during Soviet times, but after Ukraine's independence, it was almost abandoned due to the lack of new rowing equipment. DOSAAF, the paramilitary sports organization, used to manage it, and after the Soviet Union disbanded, its functions were transferred to the Society for the Defense of Ukraine. However, rowing boat production never resumed. So, we started making fiberglass rowing boats called 'yals' in Mariupol.

Here in Dnipro, we resumed production as well. We have five yals here, and one will go to Odesa this season. A yal is a 6-meter-long, 2-meter-wide boat for 6 rowers. It's not a fitness machine; it's primarily for sport. The difference is that fitness doesn't involve competition, but rowing does. We hold competitions from the first day people join the club. For example, we organize events for schoolchildren: 90 kids come, we divide them into teams, they get used to the paddles, and then they compete. We're planning to do the same thing in Dnipro with 1,500 patrol police watching. The rowing competition we held in Mariupol was popular, but we haven't been able to make it popular across Ukraine because it's expensive and building a rowing base isn't easy. In Mariupol, we perfected a drill to promote rowing in other regions, and now we're trying to do the same in Dnipro.

In Mariupol, every investment in the pedestrian areas near the yacht club boosted its appeal. After we built the second pier, the area became a major attraction. We held competitions near the pier, and people strolling by would stop to watch. When they liked what they saw, they often came back and joined the club. Right before the war, we were planning to build a water stadium with one of our competition sponsors. We wanted to install buoys with lighting and sound all around the pier.

Our yals are perfect for outdoor recreation. Traveling from Kyiv to Dnipro by river, or even navigating the entire river length, is an amazing experience. This was popular in Soviet times; we used to travel a complete circle along the Azov Sea coast. Nowadays, people would be willing to pay a lot for such an adventure, comparable to a hike to Everest. But the water is off-limits right now, and we can't change that until the war ends.

I was recently elected president of the Seaside City Federation, which gave me a chance to study the situation in different parts of the country. Both Cherkasy and Kyiv suffer from limited access for vessels. For example, the sailing federation is struggling because they need more space on the water. We can sail close to the shore on our yals, but their sailboats can't, limiting their practice areas.

We focus on several activities: training, competitions, and water trips. We also plan to add a sailing component by installing sails on the yals, allowing for both sailing and rowing. I want to make it possible to hold competitions where teams paddle part of the route, switch to sails, and then paddle again before the finish line. This has never been done before because the technical capability didn't exist. It's going to be a lot of fun for both participants and spectators.

My long-term vision is to create a service where you can open an app, find the nearest available yal, and book a time slot to use it. It would work similarly to rental scooters: people unlock the boat with a QR code, go rowing, and then return it to the pier. Every yal would come with paddles or a sail included.

What could derail all our ambitious plans? The war, of course. It's hard to plan far ahead right now. But I believe we will succeed eventually. Hopefully, the state will fund our project. If not, we'll still succeed; it will just take longer.

4.8. Respected heritage and culture

Introduction

The Dnipro River has always played an important role in Ukrainian culture. Unfortunately, Ukrainian culture has suffered a lot. Paintings, books, artworks, and music were hidden or destroyed by other empires, as is happening again today through Russian state interference. In Chapter 3, it is described how the Soviet regime, by developing reservoirs, covered large parts of the landscape and villages with water, leading to the destruction of Ukrainian heritage. Decades later, it is understood that beneath the six large reservoirs, a part of the country's history can be found.

The implications for the recovery of Ukrainian identity are not clear at this moment due to daily attacks. However, in this chapter, we explore the opportunities. This heritage can potentially be rediscovered, including parts of houses, villages, farms, churches, and roads. The cultural quality can be described as a combination of lost heritage, existing heritage, and culture, along with modern culture - bridging history to the future. The responsibility for this recovery does not solely lie with the government. Local networks of historians, artists, curators, and activists can develop bottom-up movements and initiatives.

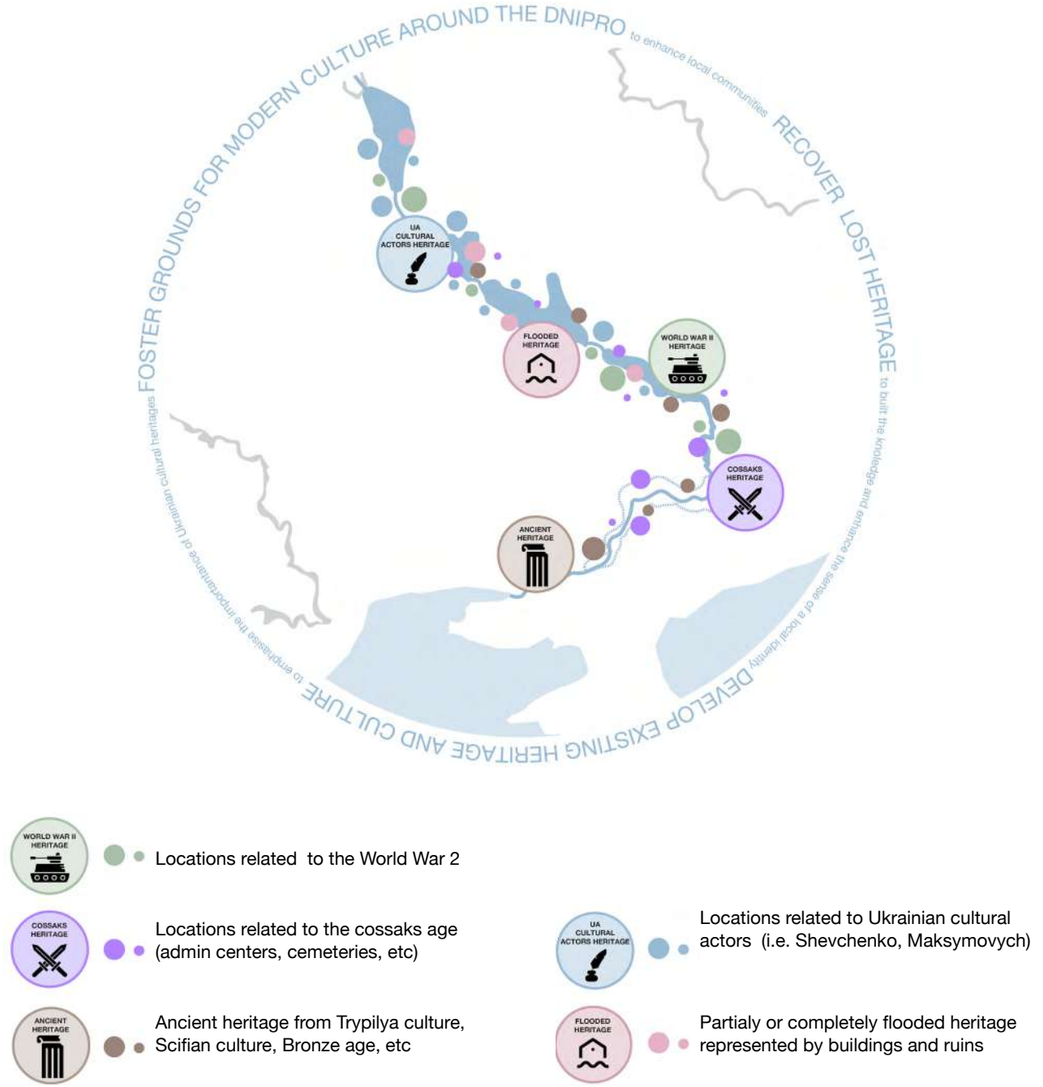


Figure 1. Infographic map of heritage and culture sites along the Dnipro River
Author: Elaborated by Ro3kvit and Greenpeace CEE

4.8.1. Reviving and preserving the lost heritage of the Dnipro River

All eras are somehow ‘stored’ and can be revisited. The main historical groups of river-related heritage are:

- Buildings/ruins on the water (flooded villages)
- Ancient settlements
- Locations related to Ukrainian cultural actors
- Locations related to Cossacks
- Locations related to the 2nd World War

From the perspective of cultural heritage different approaches can be seen. First of all a full scale recovery of all land is an option. Of course, removing all dams and giving the river its original natural shape, will not be an easily made decision. But from the perspective of heritage it is promising. Looking more precisely, a second option could be to look at the most culturally valuable and important places to restore, and start interventions in those reservoirs. The third option would be to highlight the heritage without being able to reach it physically. The heritage will be represented by other means, like information on the embankments, memoralisation statutes or boat trips. For all options, more research into possible locations and states of heritage would be recommended. Somehow, the soviet period is also part of the heritage. This can be remembered as well. Not to embrace the ideology, but also not to put away. Elements like industrial buildings, relics of a dam, or steel gantry cranes can be important anchors for memories and redevelopment. It is highly recommended to do research on the locations, the stories and the physical state of heritage that is in the reservoirs, covered under water. The start is to develop the knowledge and build a ‘library’ of media (books, websites and movies).

4.8.2. Fostering modern culture around and about the Dnipro River

The existing cultural heritage along the river should be part of a national development that restores identity and culture. Places of heritage create awareness that will lead to a new cultural and economic balance. The Dnipro River is centrally located and easy to connect from different parts of the country, and therefore an excellent opportunity to become one of the cultural backbones of the country. Recommendations include:

- Emphasise the importance of Ukrainian cultural heritage during discussions about the general development of the Dnipro River as a crucial symbol in the national identity.
- Make the heritage visible and physical: create criteria and a list of monuments or relics around the river where people can come, visit and learn about the history.

The river was an inspiration for artists and architects in the past. And so it will and can be in the future. Foster modern cultural initiatives in cities and villages along the river and support them in creating new Dnipro-related work. The initiatives should be initiated and supported on all levels. Cultural organisations from large cities should develop this not only highly appreciated but also smaller and more local initiatives can build new narratives around the Dnipro-culture.

An extensive program for cultural identity and heritage with the support of international funds and national coordination is recommended. When including the Ministry of Culture in the future thinking of the Dnipro River, there is a potential to connect the topics of water with economy and culture on a ministerial level.

4.9. Improved safety and security

Introduction

As discussed throughout Chapter 3, the Dnipro River — and thus the people that live on its banks and that consume its water — are faced with a number of significant threats and risks. Of course, there are many security concerns related to the war, be it direct military activities, hazardous military waste such as mines and explosives, or, for instance, risks related to the energy system, namely the russian military occupation of the Zaporizhzhia nuclear power plant. These immediate safety concerns understandably remain the prime concerns as long as the war continues. However, health and safety depend on a much wider set of "parameters", which should also be taken into account. The quality and quantity of available water are crucial for maintaining basic human needs, not only hygiene and sanitation but also food security and economic well-being. The preservation of the environment, aside from saving and supporting the lives of various species, also provides a great variety of benefits and ecosystem services (cultural, recreational, aesthetic, provisional and other values) that have a significant impact on our well-being. During martial law, the river and the seas are forbidden areas: the water is under military control. However, after liberation, the topic of safety and security will stay high on the agenda. For this, we provide a first set of eight recommendations.

4.9.1. Demining and clearing of river banks

The main topic of security and safety in the Dnipro River is demining. Demining and securing rivers are essential tasks from the point of view of ensuring people's safety, preserving the environment and developing the economy. Here are some critical aspects of their importance:

- *Protection of human lives*: The presence of unexploded explosives in water bodies poses a danger to the life and health of people, especially those who use rivers for water activities such as fishing, tourism or transport. The Dnipro River performs all these functions. Many populated areas are located near rivers, so it is important that these areas are free of hazardous objects. River demining helps ensure the safety of residents and provides them with peace of mind and a sense of security.
- *Environmental protection*: Mines and other explosives left behind by war or military conflicts pose a serious threat to the environment. They can lead to water pollution with harmful substances contained in them, as well as to the destruction of ecosystems and the mass extinction of species.
- *Economic development*: Rivers are important sources of water for irrigation and transporting goods. However, the presence of mines in rivers can complicate work and even stop economically important projects, such as the construction of hydroelectric power plants or waterways.

We fundamentally need to take additional measures to prevent possible negative consequences in connection with the extremely important task of ensuring the safety of rivers and coastlines from the consequences of mining and hostilities, as well as the preservation of reservoirs and energy facilities.

Taking the possible threats of landmines and hostilities into account, it is necessary to intensify measures to clear the territories along the rivers and on their banks. This requires cooperation with military units and specialised demining organisations. It is also important to involve all available foreign experience, first of all, the experience of the countries of the Balkan region (Bosnia and Herzegovina, Croatia, etc.), as well as the experience of Laos and Cambodia. During the Yugoslav wars, the coast of Plitvice Lakes was mined by all warring parties. Maps of minefields were not drawn up, and later, local authorities and international organisations spent a lot of effort on the complete demining of these fabulous places. However, "echoes of war" are still sometimes found here.

The involvement of modern technologies – artificial intelligence and all available robotic means to reduce the possibility of human injury and death during the search and demining of reservoirs. Some progress can already be recorded: UADamage has been activily using such modern technologies to demine Ukrainian territories, but also performed a scan of the Kakhovka reservoir. Denmark has also handed over one complex to Ukraine for searching for mines in the water. The need to create and execute demining programs for the river and the river banks is evident and remains a priority for the return to the safe use of the waters of the Dnipro River.

4.9.2. Further measures

Maintenance of hydraulic structures

When considering the issue of improving the safety of rivers, it is necessary to pay attention to the need for regular inspection and maintenance of hydraulic structures. It is important to emphasise the improvement of monitoring and control systems for the state of dams, locks, and other hydro-technical structures that ensure the safety of river systems. Implementation of public outreach systems, such as an app where residents can report potentially dangerous finds. An example of such an application is developed in Bosnia and Herzegovina (EUFOR).

Use of modern technologies

To ensure effective security of water reservoirs and power facilities, it is worth considering the implementation of modern monitoring technologies, including video surveillance, drone patrols and sensor systems. Such measures will help to identify potential threats in time and respond to them. The Danish complexes mentioned above can become such measures. It is also possible to hold hackathons and grant programs for the development of humanitarian de-mining startups, in particular reservoirs and the coast of the Dnipro River.

Civil society engagement

It is important to establish close cooperation between all stakeholders, including authorities, local communities, academic institutions and civil society organisations. Only through joint efforts will we be able to achieve a significant increase in the safety of rivers and coastlines, preservation of water reservoirs and energy facilities.

Border-emergency plans

It is recommended to develop emergency plans for the Dnipro River. In this, special attention needs to be made related to waste and chemicals entering from Russia and Belarus via the water. Also, the water supply can be cut off from the north. Evacuation plans should be made and communicated with the local (and regional) communities.

Communication and information

Intensify information work with the population regarding safety rules near rivers and reservoirs. This includes the distribution of information brochures, advertising on social networks, the creation, implementation and delivery of training events and publications in the media. Broad involvement of international humanitarian organisations, as well as the involvement of the veteran community to share experience and expertise that is “not in the text books.” This is probably one of the most important parts of this process, because this is a new experience for the country, which, unfortunately, has spread to the entire territory since 2014. The first defense against injuries is awareness.

Part 5
Integrated strategy – first steps

Contents

Summary

The previous chapter described in detail the strategies and recommendations with a separate focus on the different themes (or as we previously called them – layers) related to the Dnipro River, including energy, industry, agriculture, water use, security, and leisure and culture. In this section, we try to bring together all the previous recommendations, reflections and strategies into a more general picture of an integrated vision for the future development of the Dnipro River. Therefore, this section includes the following: (1) general conclusions, (2) three potential scenarios for the development of the Dnipro River, and finally (3) a list of recommendations for local communities to achieve the identified goals.

It should be noted that the creation of this report and the formulation of strategies for the development of the Dnipro River were based on the data and knowledge available to us at the time of the study. A great deal of work has been done in researching the past and present context of the Dnipro River and its history, which is extensively presented in the first three chapters of this report. However, the scale of the river and the wide range of topics explored inevitably faced many limitations, both in terms of availability and access to relevant sources and data, and in the resources required to explore the various aspects and topics described in this study in greater depth and detail. Undoubtedly, the uncertainty associated with the war also forces us to consider and take into account a wider range of possible scenarios, and calls into question the relevance of much of the data collected before the full-scale invasion. Despite all these difficulties, we have tried to provide the highest quality and most objective analysis possible, with the understanding that some opinions or facts may no longer be relevant.

Although we know that the future of Ukraine and the river depends on many variables that cannot be predicted, we believe and hope that Ukraine will be able to regain control over the temporarily occupied territories and ensure security throughout its territory. Regardless of future developments, we would like to emphasise that our research is only an initial stage and that any final decisions on development strategies for Dnipro will certainly require more detailed research. The aim of the authors of this report and this vision remains, first and foremost, to (1) provide a general context and understanding of the significance and potential of the Dnipro River, both for the general population and for those individuals and institutions in a position to influence policy changes in a meaningful way, and ultimately (2) inspire these various actors to continue our work to address the risks and develop the Dnipro River and Ukraine. We believe that the ideas presented in this report can be used to inform further dialogue at the national and local levels.

5.1. Principles for a future-proof flow of the river

Key princples to follow

Based on the information presented in the previous chapter four, we have identified four general conclusions about the future development of the Dnipro River, formulated as so-called ‘principles’. These conclusions are the basic principles that we believe should be followed in any further steps related to the development policy of the river or its riparian areas. In a time of war and resource scarcity, these principles are intended to help guide decision-making based on a sustainable and holistic vision that is future-oriented.

Principle 1. The Dnipro River Basin is a source of life in all aspects:

By source of life we mean more precisely:

- Source of healthy water for people (hygiene, sanitation, utilities);
- Source of clean water to maintain a healthy natural environment (flora and fauna);
- Source of sufficient water for economic use (industry, agriculture, etc.);
- A symbol of Ukraine’s identity and culture.

The river provides water for all of us, but to maintain and fulfil all of these needs, it is necessary to determine the right balance and use of water resources.

Figure 1. Diagram visualizing key components of the Scenario 1.
Elaborated by Svitlana Usychenko based on the data provided by the team

Principle 2. The technical focus of the Dnipro River must be informed and complemented by natural, cultural and social viewpoints.

Over the past decades, the Dnipro River has been viewed mainly from a technical perspective. The river’s potential can be enhanced by taking a more holistic approach and bringing economic perspectives into positive balance with social, natural and cultural development. For the Dnipro River, we have identified a number of key themes or ‘layers’. The main layers are the quality and quantity of groundwater and surface water sources, prevention of pollution, maintenance of biodiversity, supply of industry, economy, agriculture, recreation and tourism, a safe and efficient energy system, accessibility and openness of the river, mobility and transport, heritage and culture, and of course, security.

Principle 4. Decentralised energy generation for a resilient future.

Rethinking the role of the Dnipro River in centralised energy production in Ukraine will highlight the need for smarter and more efficient use of energy in cities and villages. It will also present more climate-neutral and sustainable solutions for decentralised and democratised energy production. By decentralising the system, the impact of energy consumption on the river will be reduced and alternative uses of the river will be available. The importance of existing hydropower and nuclear power plants may be rethought as alternatives prove to be more sustainable (and in the long run also cheaper).

Principle 3. One Water Approach for the Dnipro River Basin.

Water planning in the Dnipro River basin should be in line with the One Water approach, which involves the integration of planning for three infrastructure systems: water supply, wastewater and stormwater. The One Water approach describes water sector planning processes at a level that meets European standards. This paradigm aims to replace the fragmented systems of the industrial era with sustainable, interconnected strategies. Benefits include improved resource sustainability, ecosystem conservation and flood avoidance. The interconnectedness of water systems is central to this approach, emphasising integrated management to prevent problems in one area from affecting others.

Principle 5. The future of the Dnipro River should be widely discussed.

Open and interactive dialogues, debates and discussions: all this is necessary to create a process that will ensure a high level of understanding of the Dnipro River’s potential. We plan to organise or participate in many different events to tell the story of the Dnipro. The events can be informative, such as lectures, interviews or presentations. They can be creative, such as workshops or events. They can also be decision-making-related, such as public hearings or political discussions. We hope to involve many active organisations and a wide audience. We believe that the Dnipro River is too important to be discussed only in a narrow circle of professionals.

Interviewing
Arsenii Boiko

High school student
14 years old
Lives in Kremenchuk

I live a pretty typical teenage life: I go to school, ride my bike, and play volleyball.

My first memory of the Dnipro is from when I was 10 years old. It was my friend's birthday, and we were just chilling by the riverside promenade. I had just gotten a new phone, my first one with a decent camera. I wasn't really into taking photos, but everything around the river looked so cool that day, so I decided to snap some pics. I ended up taking a bunch and had a blast.

When I got home and checked my photo gallery, I was stoked with how the pictures turned out. They weren't masterpieces or anything, and I didn't think I was some genius photographer. But it made me feel proud that my city has such a beautiful riverside promenade.

I see the river as a place of comfort, where you can go to think about your problems, clear your mind, or just hang out; it's a great spot. The promenade is usually pretty crowded, but if you walk further down to where the pebbles are, you can be alone with your thoughts. Sometimes I really need that. The river helps me think and relax.

One of my most vivid memories of the Dnipro is from one evening when I was riding my bike alone, lost in thought. Suddenly, I heard dogs barking and saw three or four strays chasing me. I started pedaling faster to get away from them, but then I looked ahead and saw this incredible crimson sunset. That's when it hit me: those dogs weren't chasing me; they were running towards the river to watch the sunset. It was such an inspiring moment and it's still a powerful memory for me.

I know a lot of the stuff I do at home involves water. I use it to brush my teeth, take showers, make tea, water the plants, you name it. And I know all this water comes from the Dnipro. I also spend a lot of time by the Dnipro, whether I'm chilling on the promenade or hanging out by the riverbank. Without the Dnipro, our city wouldn't be nearly as cool to live in. I love the smell of the river. It's got this special freshness, like the air after it rains.

To me, it also smells like hope — hope that Kremenchuk has a future.

The city's life is so connected to the Dnipro. To keep the Dnipro awesome in the future, I think we need to have bigger fines for polluting the water, especially for big factories. And for people who litter near the river too, because the wind just blows it all into the Dnipro. We should also have more trash cans around so people have a place to throw their garbage after a picnic by the water. If people see trash cans, they're less likely to litter.

Maybe we could also offer some kind of reward to get people to walk along the river and pick up trash. That way, it's not just a few enthusiasts doing it, but everyone.

Whenever I think of the Dnipro, I picture it like a living being trapped in a cage. It's almost completely controlled by people.

If the Dnipro does something they don't like, they just try to suppress it. It's like a prisoner behind bars, with its captors doing whatever they want to it.

The biggest threat to the river is that it might just disappear if people keep wasting water at home. Or it could get so polluted that we can't use it at all for years. I think we should at least try to use less water. Like, when you're brushing your teeth, just turn off the water while you're not using it. And it's important to clean up the trash on the riverbanks and clean the river water as much as we can.

We also need the authorities to pay more attention to when the river is getting harmed. For example, ...

... hydroelectric power plants aren't doing the Dnipro any good. If we get rid of them, the river can flow naturally again and clean itself. I really hope that happens someday.

5.2. Integrated scenarios for the Dnipro River

Introduction

In this section, we want to show in more detail how interconnected all the layers we discussed earlier are. We will look at three potential scenarios for the future development of the Dnipro and its river basin, analysing how certain decisions may affect other areas. Scenario-based thinking in regional or urban planning is usually intended to fuel discussion, debate and further research. Scenarios are used to help people rethink their vision, to open up different interpretations when combining all levels, themes and layers.The scenarios are based on the logic of what has happened from February 2022 to date.

- **Scenario 1: Restoration of the Dnipro River as it was before the full-scale invasion.**
- **Scenario 2: Redesign in an eco-friendly way in those places where structures and flows are damaged or changed**
- **Scenario 3: Re-naturalisation: returning the river to its natural flow.**

These scenarios are not designed to force residents or decision-makers to make a final choice in favour of one of them. The final decision may be somewhere in between, more flexible and detailed. The whole river does not need to be treated equally, nor do all the recommendations need to be or can be implemented at the same time. Therefore, scenarios help to make a more flexible proposal. To initiate and facilitate the discussion, we provide the main advantages and disadvantages of all three scenarios.

Figure 2. Drone footage of the Dnipro River South of Kyiv
Author: Antoine Korchagin, 2020

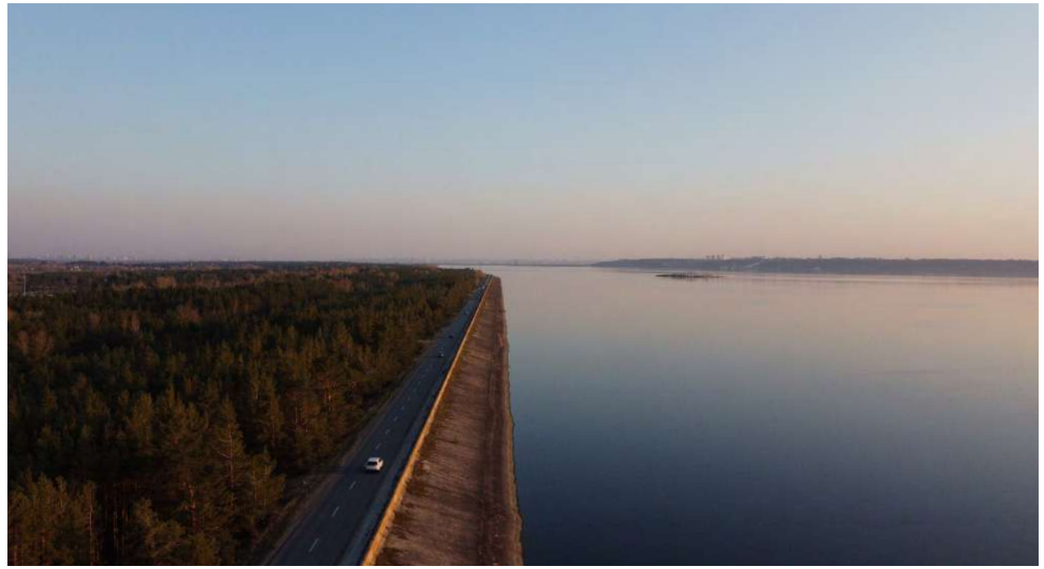


Figure 3. Drone footage of the Kyiv Reservoir of the Dnipro River
Author: Antoine Korchagin, 2020

Scenario 1. Restoration of the Dnipro River as it was before the full-scale invasion

The first scenario of river restoration is to return the river flow to what it was before the full-scale invasion of Russia in 2022. Under this scenario, bridges and dams that were destroyed or damaged would be rebuilt or repaired. Reservoirs will be restored and function again to meet various water needs for the municipal sector, agriculture, industry, etc. This scenario will not just mean a return to the way things were before, but may include improvements in some areas and aspects, such as: environmental monitoring and development, open and accessible embankments, preservation of cultural heritage, and improvement of water quality through updated water and wastewater treatment technologies. Investments will be project-oriented, based on a list of improvements in these areas.

In favour of this scenario is:

- The technology is a proven concept
- It is relatively fast to get to this point again.
- There are enough other challenges to take care of after the war, let's keep this simple and the way we knew it
- It will solve the issue of water supply to the southern regions and the Crimean peninsula.

Against are the arguments:

- The war is still too close to the river in the Zaporizhzhia, Kherson and Mykolaiv oblast. It is too dangerous to restore.
- It is unknown how many Russian mines are placed in the river, the embankments or in reservoirs.
- Even after the current war has ceased, large centralized hydropower plants will continue to be vulnerable to possible future resumption of hostilities as dams and hydropower plants are easily targeted and destroyed and result in very significant consequences for man and environment.
- The life span of some of the hydro structures is limited, and regular maintenance and needed repairs are way behind schedule. Large investments will be needed in a few years anyway. This can be a reason to rethink the viability in these times.

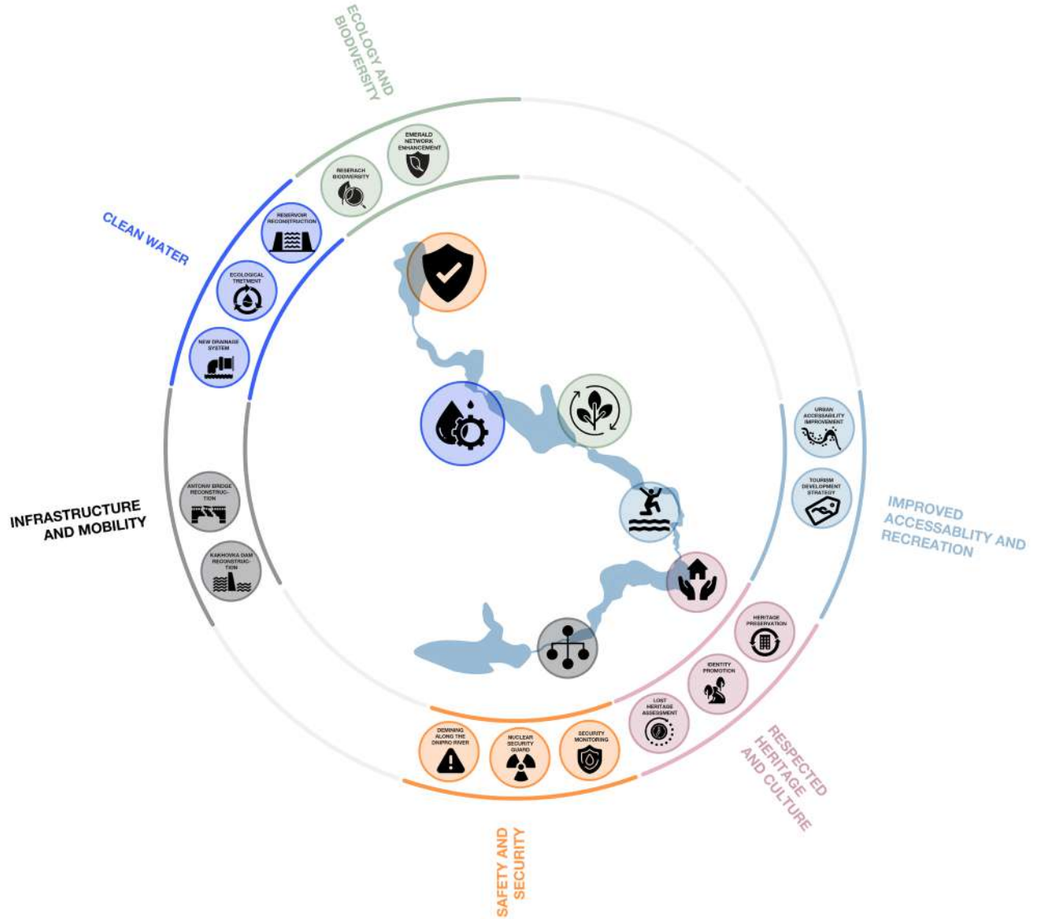


Figure 4. Diagram visualizing key components of the Scenario 1.
Author: Elaborated by Ro3kvit and Greenpeace CEE

Scenario 2. Redesign in an eco-friendly way in those places where structures and flows are damaged or changed

We see old river structures (reservoirs, dams, bridges) that have been destroyed or are heavily outdated and in need of restoration. We suggest not to simply restore them, but rethink the situation and move forward towards a more eco friendly approach. In this scenario there will be site specific solutions. All of them based on the general principles as mentioned in 5.1, but with different outcomes and results. In this second scenario the existing situation will be examined step-by-step, from place to place. The situation is so complicated that a standard approach will not work. For example, around the Kakhovka reservoir another solution must be found, because the dam has already been destroyed. Also, the Anotonivska bridge is down, so in this region a new vision of connectivity, energy and ecology will be needed. In contrast, in the area of Cherkasy or Kremenchuk, for example, the situation does not urgently require large-scale interventions. Of course, all of this depends on the development of the war to come.

In favour of this scenario is:

- This approach will be budget efficient, with no loss of financial capital and urgent issues solved first.
- The solutions will follow main principles but will be site-specific, and less top-down planned. It is easier to include local knowledge to improve the plans.
- We can learn step by step, and imrpove the situation with the latest knowledge.
- The Ukrainian society will be able to adapt to the changes gradually.
- Maintenance costs and investments will be spread over several years.

Against are the arguments:

- Climate change does not allow us to wait longer and urges us to make more climate friendly solutions.
- The alternatives for peak energy supply are not easy to reach, looking at the scale of the country. Prices for investments in technology for this are high.
- This scenario might lead to fragmented solutions, thus jeaporadizing the effectiveness of innovations and investments.

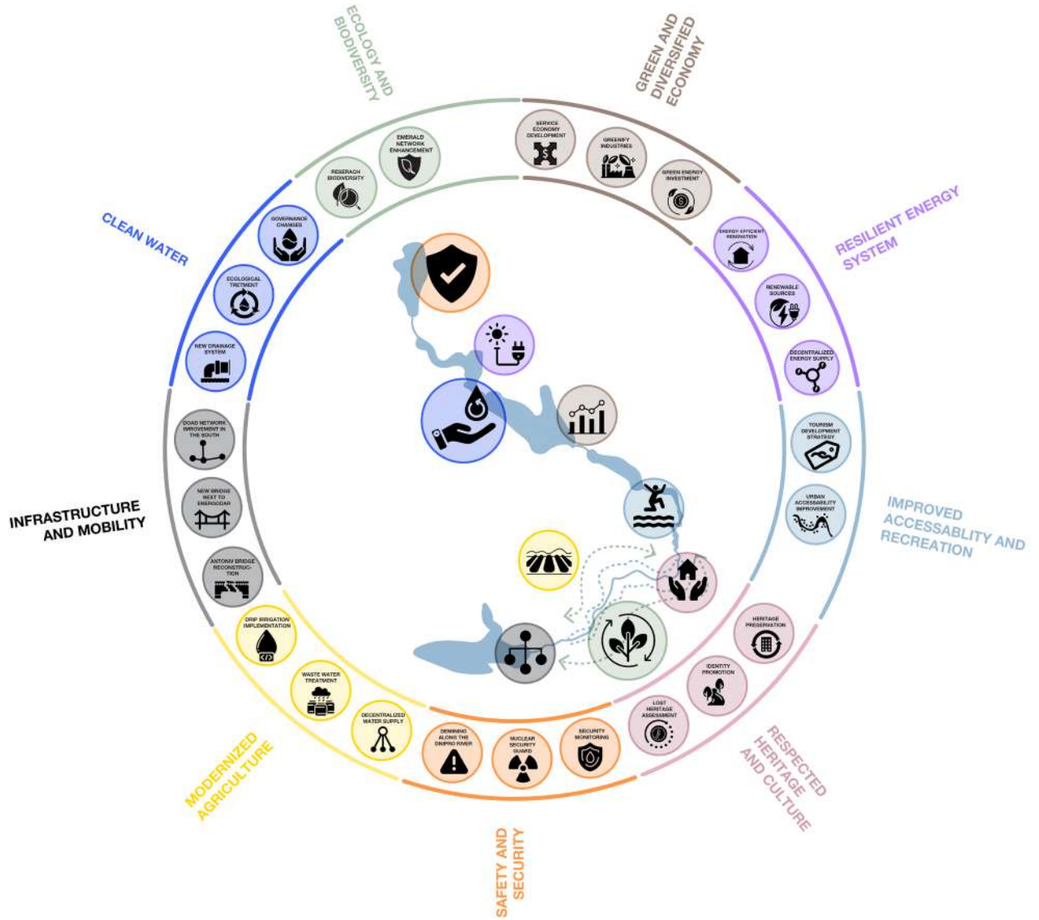


Figure 5. Diagram visualizing key components of the Scenario 2.
Author: Elaborated by Ro3kvit and Greenpeace CEE

Scenario 3. Re-naturalisation: returning the river to its natural flow.

In this scenario the reservoirs and hydropower stations will be removed, and the energy peaks will be covered by other energy sources. The natural flow will give flora and fauna a boost and the ecology will be supported by new natural parks and protected water zones. Heritage preservation will strengthen cultural identity next to the many touristic opportunities. Industrial and household pollution will be reduced.

In favour of this scenario is:

- The original flow facilitates a return to the benefits of earlier natural and cultural environments.
- The area of the Kakhovka reservoir shows - besides the tragedy and huge local complexities - resilience of nature and growth of species.
- It supports the need to be ready for the next big threat: climate change. It connects to the EU values, stated in the New Green Deal.

Against are the arguments

- It needs research to determine what historical natural flow is desired and whether it can be restored in the new climate and what the risks are in terms of flooding, drought or otherwise.
- The original flow contains many rapids, which will reduce the options for long distance water navigation.
- The first investment costs are relatively high, compared to other scenarios. In times of post war recovery the budgets are limited.
- Industries and agriculture businesses will need to reorganise part of their processes.

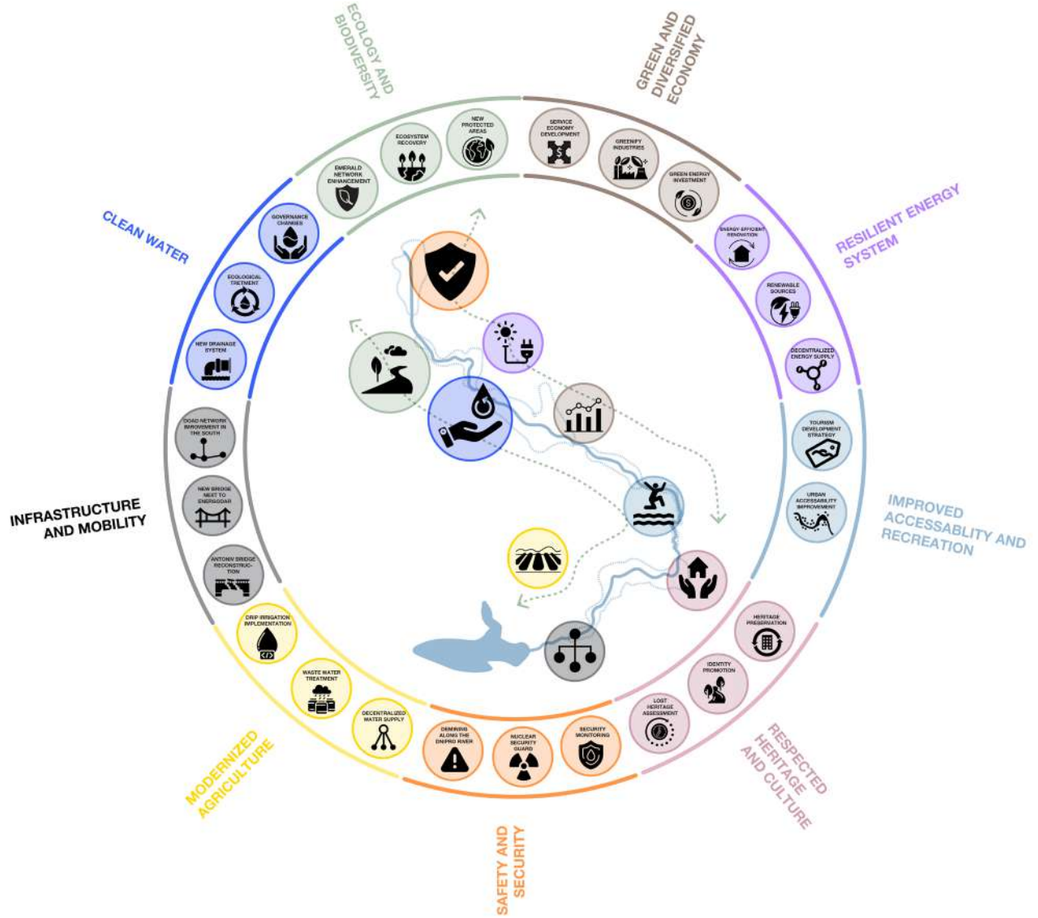


Figure 6. Diagram visualizing key components of the Scenario 3.
Author: Elaborated by Ro3kvit and Greenpeace CEE

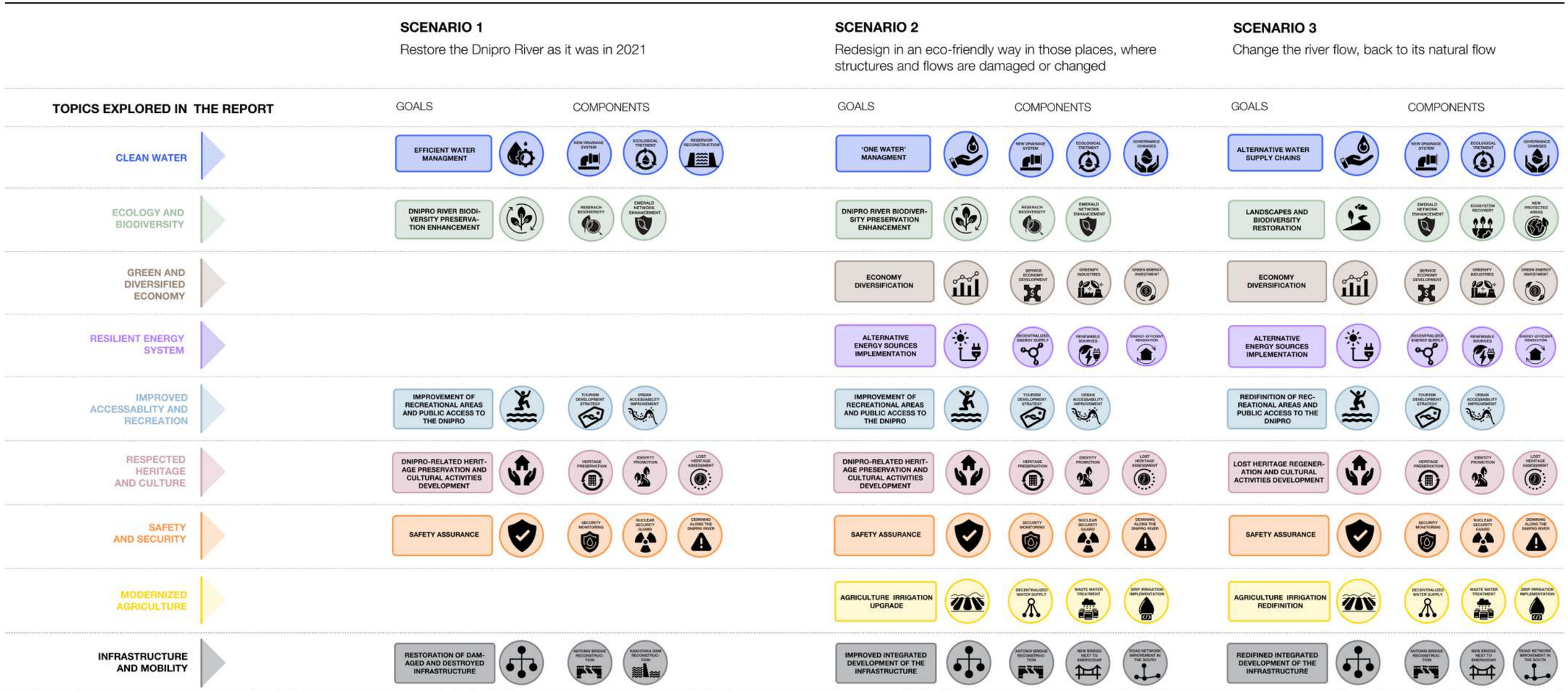
Conclusions

These scenarios will facilitate the dialogue, and will help in understanding the more detailed arguments. We recommend all stakeholders start discussing these scenarios and build more knowledge, find opportunities, and if possible and sensible: start planning.

The specific decisions needed for the people of Ukraine, for the country's economic development and the preservation of natural systems, will be made when considering the needs of all users of this resource.

A wide range of stakeholders (farmers, energy producers, decision makers, industries, consultants and the local population and so on) will discuss site specific approaches and needs and take into account old and new technologies, for water distribution, irrigation systems, energy sources, based on a detailed calculation of all pragmatic and ecological options.

Figure 7. Goals of the possible scenarious and related components for the integration. Source: Elaborated by-Ro3kvit and Greenpeace CEE.



Interviewing
Dmytro Ivanov

Journalist civic activist
57 years old
Lives in Kyiv

The Dnipro is a part of my life. I spent my childhood on its left bank, and the river was always in front of me, right outside my window.

I'm a journalist by profession, but I've also been an activist for over 10 years. My activism began with defending the Dnipro in 2007. I'm one of the leaders of the National Ecological Center of Ukraine, one of the oldest environmental organizations in Ukraine. Founded by renowned Ukrainian scientists, it still brings together professionals, not just activists. Many of our specialists are experts in water issues: hydrologists, geohydrologists, botanists, geobiologists, and more. We're involved in protection projects and environmental policy, and we're fighting against hydroelectric power. I'm an opponent of the Kaniv pumped-storage power plant project, which was planned during Soviet times, then abandoned, and now revived.

What's happening to the Dnipro is the result of long-term problems from the Soviet era. Solving them requires collective efforts from the entire nation, as it's our national responsibility to save Ukraine's main river.

Millions of people live along the Dnipro's banks, drink its water, and rely on it for various needs. The actions of both the government and public organizations need to be synchronized, with everyone sharing the same vision of what needs to be done. Only then can our Dnipro heal and restore its potential.

First, we need legislation banning the use of phosphates in everyday detergents, as they are destroying the river. People need to be educated about which detergents they can and cannot buy. The next issue is the discharge of untreated water into the river. There are practically no treatment facilities for stormwater runoff, even in Kyiv. Another problem is agriculture, which uses substances, fertilizers, and pesticides that get washed into the river by spring waters. These chemicals sink to the bottom and poison the river.

Hydropower isn't the biggest problem, but it creates issues that wouldn't exist otherwise. The reservoirs are necessary for water storage and use, but they hinder the river's natural self-cleaning process. The water flow in the Dnipro is now ten times slower than it was naturally, meaning everything in the river stays there instead of being carried out to sea. Large reservoirs are mostly shallow, so in summer, the water warms up, causing everything to decompose and bloom. This chemical mix leads to cyanobacteria and the green scum we see on the banks.

Scientists from the National Academy of Sciences of Ukraine are studying the chemical state of the silt deposits on the shore of the former Kakhovka reservoir. They've already found substances that shouldn't be there. Now that it's sand instead of water, we can study it, and this research should be done on all the reservoirs. Unfortunately, no money has been allocated for such studies. It would cost tens of millions of hryvnias, but the state should provide this funding.

The hydroelectric dams that block the river need to be removed. These are 70-year-old projects, and it's absurd to restore or maintain them. Claiming that hydropower can't be replaced is a lie.

Alternative technologies are available. The world is moving towards eliminating dams on large rivers; many countries have decided that the environment is more important than economic interests. We can provide drinking water and irrigate fields in other ways.

The State Strategy for the Dnipro River Rehabilitation was adopted back in 2012. By 2020, the plan had only been 10-20% completed, and the document expired. They promise to relaunch it, but it won't succeed unless local communities push the authorities to act. The rehabilitation of the Dnipro will be a litmus test of Ukraine's ability to unite. We need to bring together tens of millions of people to accomplish this task. Then we will finally become the nation we all dream of, with a functional civil society that can govern itself without top-down leadership.

Interviewing **Andrii Nelipa**

Civic activist, environmentalist
50 years old
Lives in Kyiv

I am an expert in ecology, water management, and the fishing industry, and I am also a dedicated fisherman. Having spent 45 years fishing, I have devoted much of my life to the water. For the past 15 years, all my activities have been intricately connected to water. Additionally, I hold a specialized degree in aquatic bioresources, making this a deeply personal and critically important topic for me.

Eventually, my passion for fishing transformed into a professional endeavor. We established the All-Ukrainian Organization of Fishermen and began thoroughly studying issues related to the fishery, including the ecological state of water bodies, shore access, fish stock conditions, and fishing regulations. I pursued further education and worked in related institutions to gain a comprehensive understanding from the inside. Today, this is my life's work. The Dnipro River was transformed into a series of six reservoirs long ago, and it is unlikely that we can return it to its original state.

Ecologically, removing the cascade and restoring the river would be highly beneficial, but from a practical perspective, the cascade serves a useful purpose. However, it is harming the Dnipro, turning it into a chain of polluted water bodies that do not clean themselves effectively.

While some negative impacts from human activity can be mitigated, we must acknowledge that the ecosystem has suffered and that human actions are significantly detrimental to it. Addressing this situation requires fundamental changes that will be costly for both the state and local communities, as it necessitates a complete reorientation of all production processes.

The practices envisioned by our grandfathers in the last century, such as relying on hydropower, are now outdated and unsustainable.

Huge sums of money are spent on maintaining hydraulic structures, water intakes, and related infrastructure. Additionally, man-made pollution resulting from equipment failures negatively impacts the ecosystem. And right now, under martial law, it is unrealistic to dismantle hydroelectric facilities, partly due to security concerns. In other countries with similar conditions, rivers are being restored to their natural channels, and dams are being demolished. We need to find a viable solution that will help us preserve the river. We don't want to leave our descendants with a polluted body of water that requires constant intervention.

For us fishermen, preventing organic pollution in the Dnipro is absolutely vital, as the river cannot clean itself. We can create a comprehensive program involving experts, local activists, and others; hold hearings and meetings; and coordinate with foreign partners—we often participate in such events. However, one significant obstacle consistently undermines these efforts: funding.

Although action plans and programs initially receive funding, it often disappears over time. When we investigate why progress stalls, authorities appointed to oversee these programs often say: 'What did you expect? The program had funding for 7-8 years, but now there's only enough to pay salaries. We can't do anything else with these funds.' For example, we have repeatedly raised the issue of the Dnipro rehabilitation program with the State Water Agency, and they respond: 'Don't blame us; we haven't received funds for this in 20 years!'

Moreover, the funding approach keeps changing. Initially, it was state-funded, then came decentralization, and local authorities were supposed to take over. But they say: 'This wasn't our idea, and we're not sure we want to spend money on this.' Then, international donors show up, complaining that the money they've been donating for 20 years has been stolen. As a result, they no longer support the old program and demand a new one. The only people still involved are individual activists and concerned communities. They come together to address the negative impact on the river's ecology.

Until there's a radical change, activists and communities are the river's only hope. I don't want their efforts to be in vain.

I can't imagine getting proper rest without water nearby. Although I don't have much time for fishing nowadays, it's vital for me to frequently visit the shore and simply gaze at the water. Watching the water helps me gather my thoughts as I observe the fish, algae, and other signs of life. There's always something happening: last year's leaves floating on the water in spring, the changing colors of the sand, and the fish swimming and splashing.

I have memories of the Dnipro for as long as I can remember myself, which began around the age of two. I even recall the first time I went fishing with my father. We have a dacha near Kyiv, close to the Dnipro. My father, may he rest in peace, was an excellent fisherman, and I've loved fishing since I was a kid. We fished all the time, even in winter, and not just on the Dnipro. Wherever we could fish and swim, we went there. My earliest impression of the Dnipro was that it wasn't just water—it was an entire world, what we now call an ecosystem. It's alive.

5.3. Guidelines for hromadas

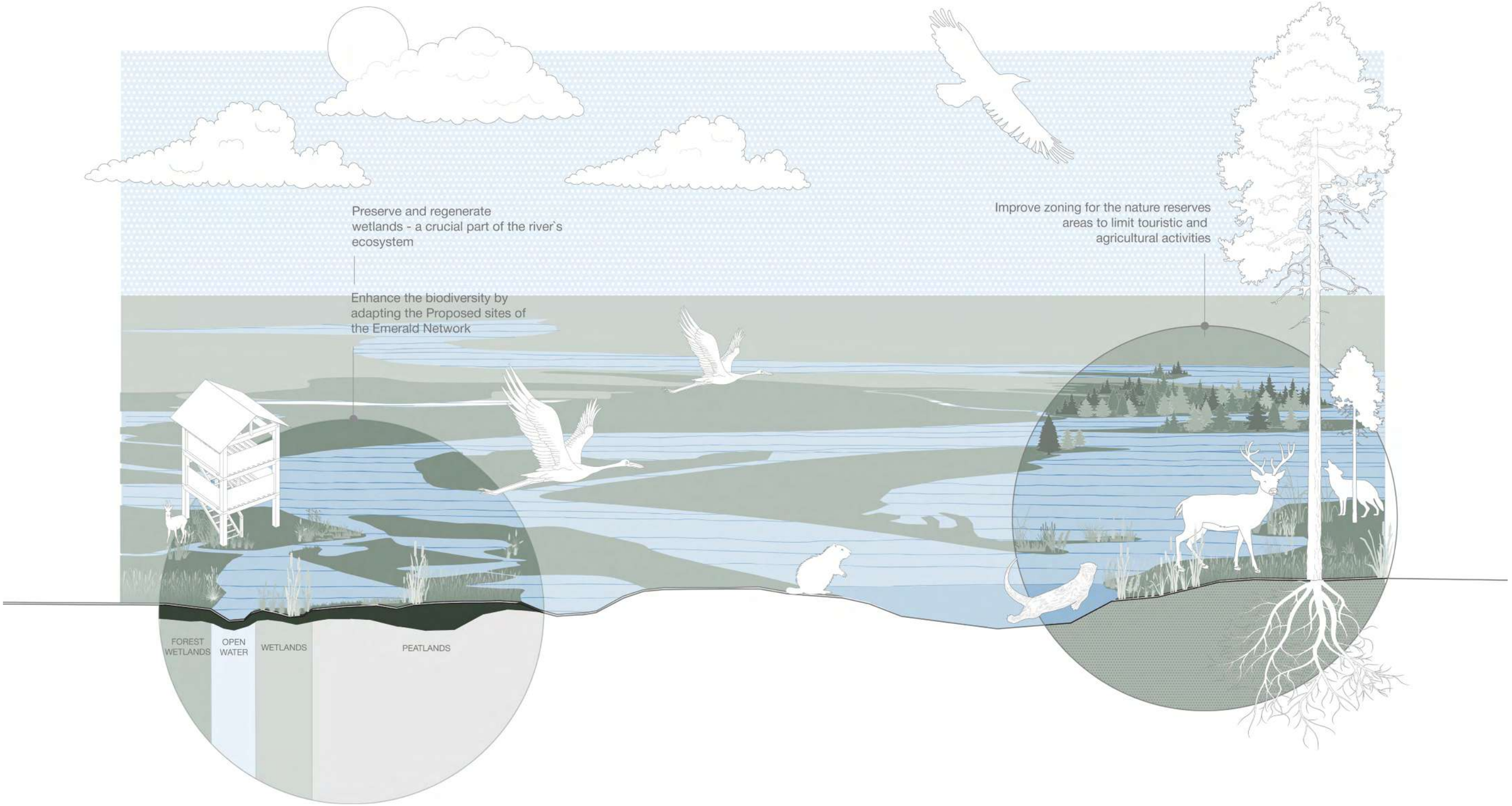
How can hromadas work locally with the Dnipro River?

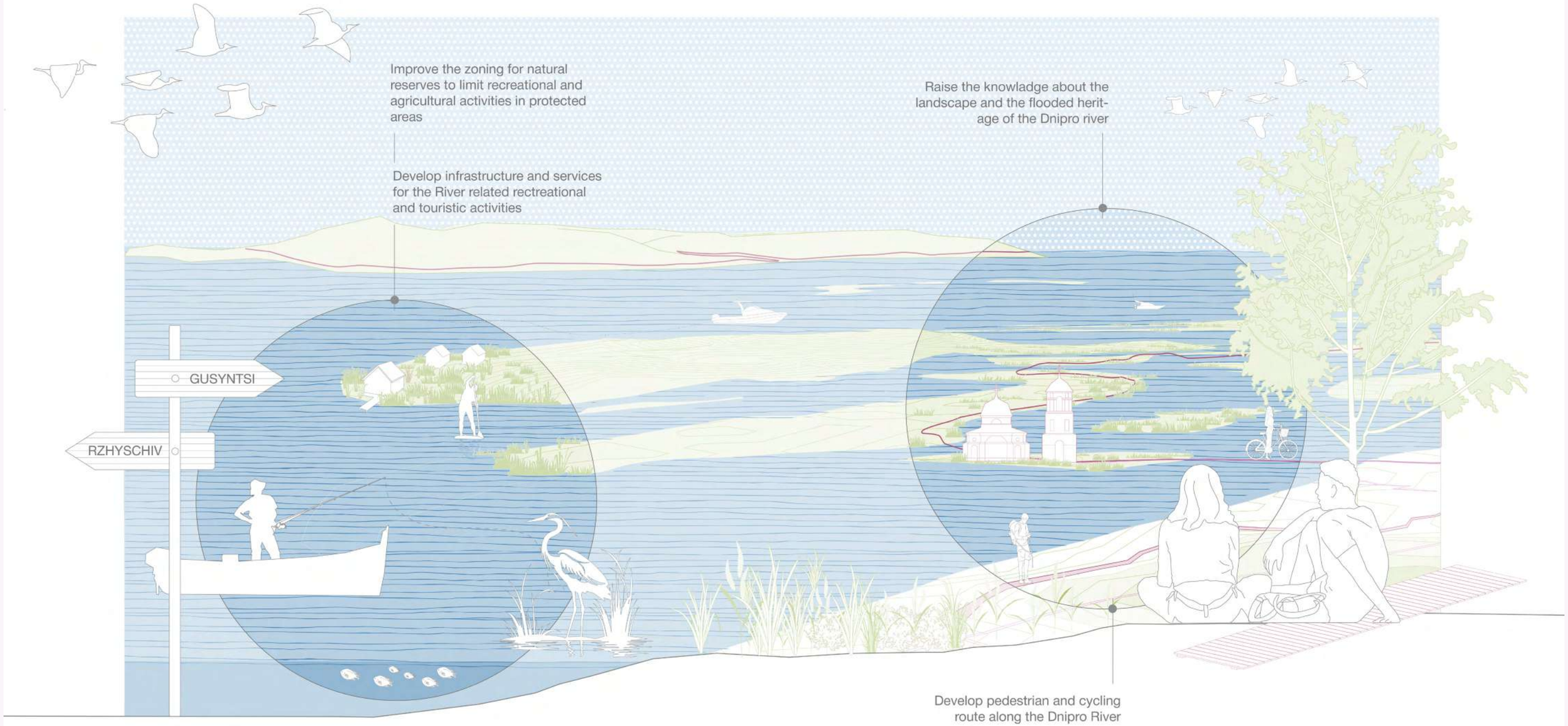
The Dnipro river has many stakeholders, on all levels. From local individuals who clean the waste at the beach, to the ministry providing legislation or connecting to donors for funding. A key player and connector in this stakeholder field is the municipality, the hromada, as it is called in Ukrainian. They have a link with local entrepreneurs and ngo's, but also with the ministry or regional authorities. They play a key role in taking initiative, giving example and integrating the approaches. Quite a few of the decisions and projects can and should be made by local authorities. The guidelines presented in Table 1 may be useful for local authorities, as an inspirational checklist. The order displayed should not be taken as rigid and can be adapted based on the priorities and local context.

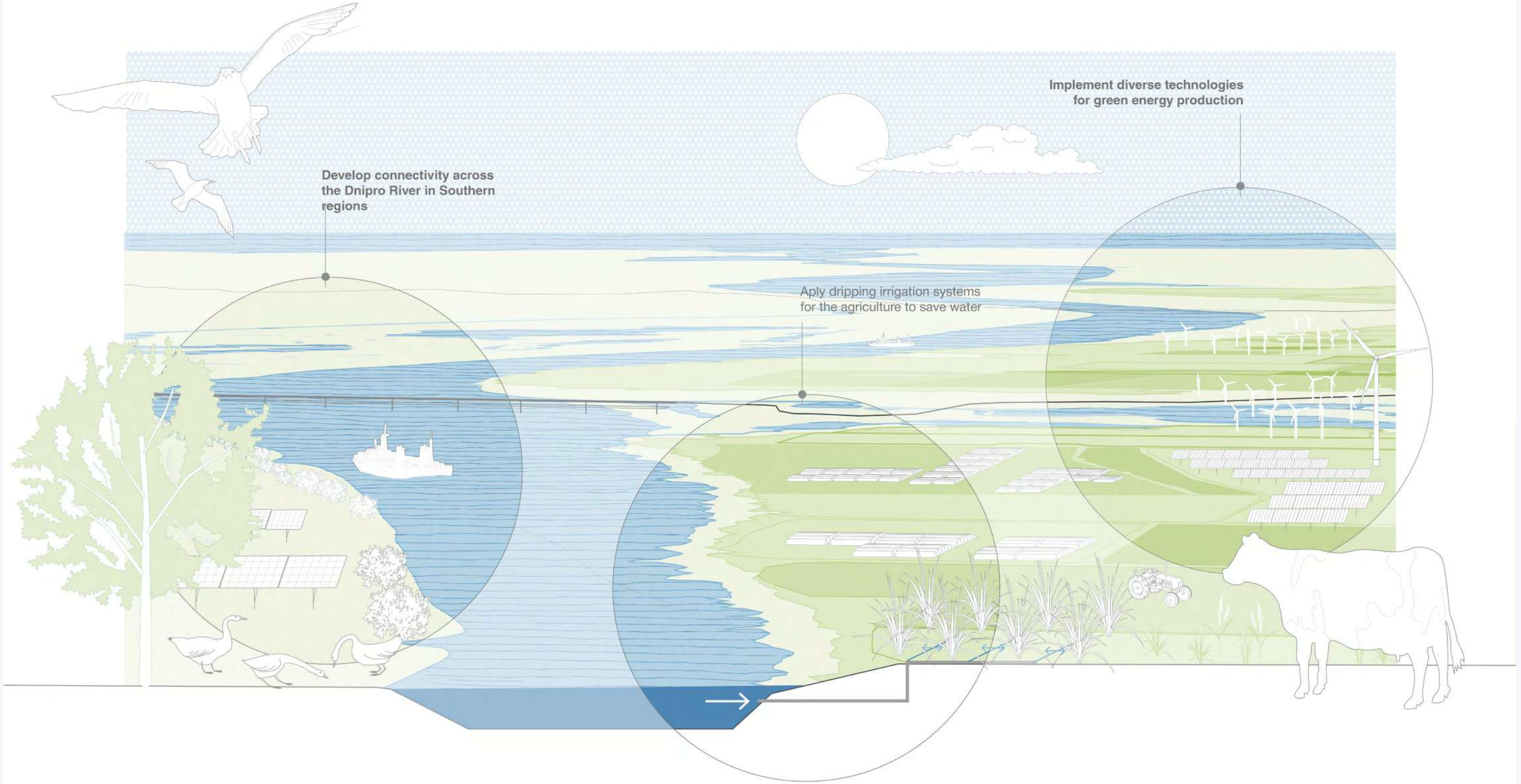
Solve locally what can be done locally.

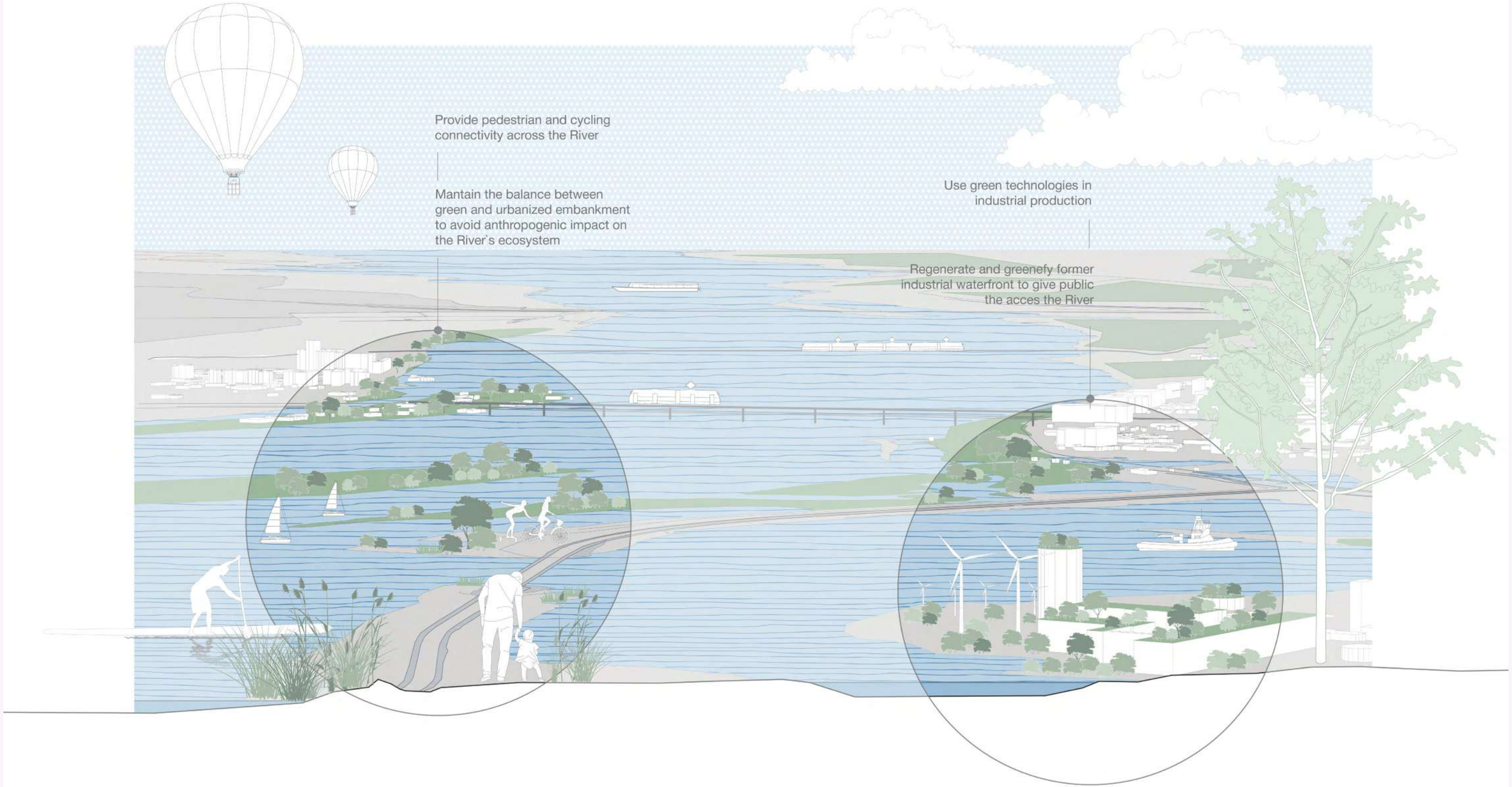
Table 1: Recommended guidelines for local authorities (order of priority can be adapted)

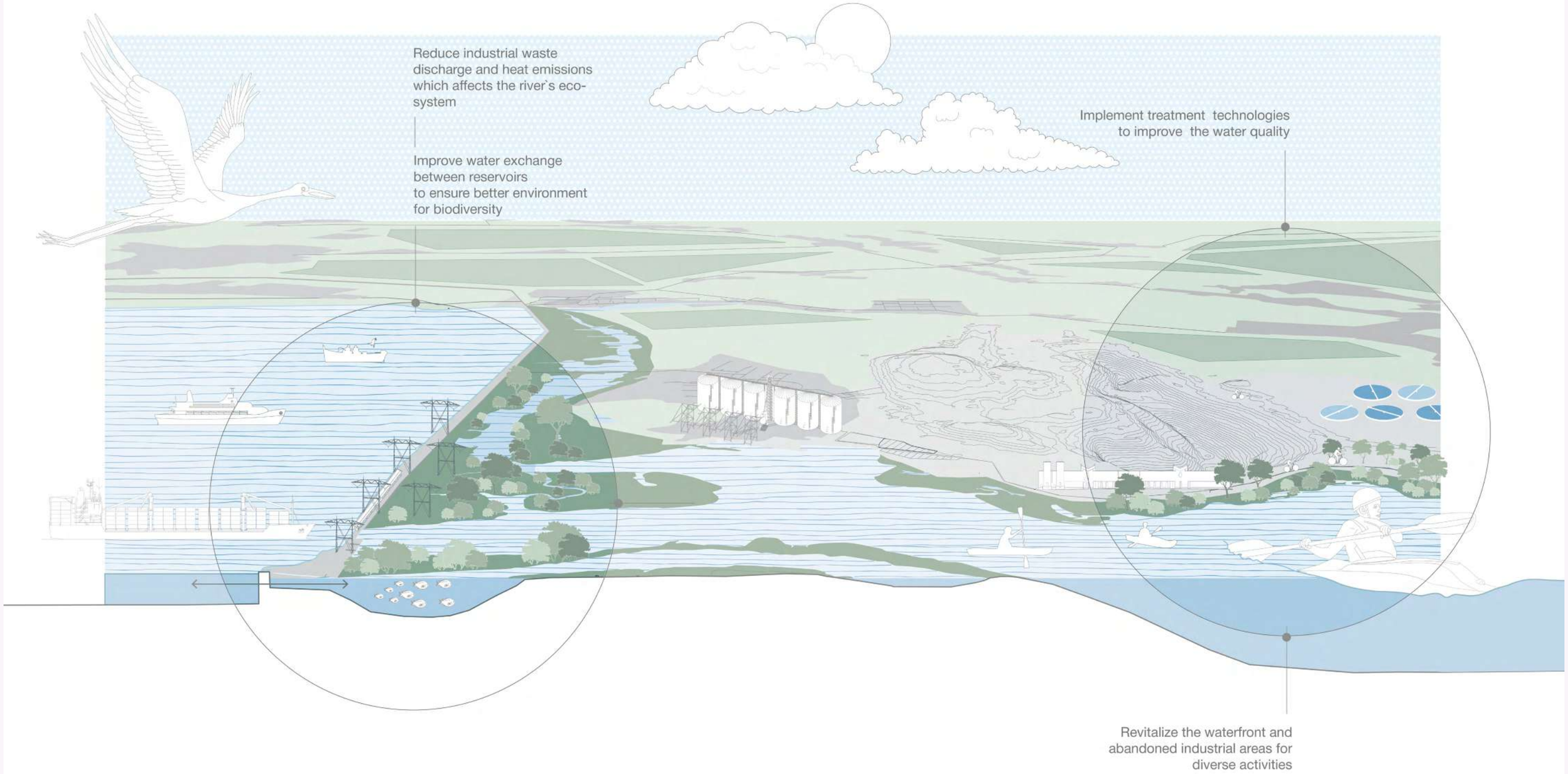
1.	Develop an integrated vision for the city and river and how they connect. These integrated visions give a context for the city plans, like integrated complex plans and recovery plans.
2.	Develop safety and security plans that include routes for evacuation and other strategic resilience measures. Connect these to other water-, energy or waste management projects and find related interests and budgets.
3.	Construction of a system for collecting and treating storm-water and sewage with the possibility of reuse.
4.	Focus on what can be done to reduce the risk of high flooding. Define what is the minimum size of the reservoir for water use, and what that leaves as a flood risk.
5.	Redefine location of industries or businesses, and reduce their impact on water pollution, by using examples of local policies from other Ukrainian cities.
6.	When reviewing the location and size of the port for trade, passengers or recreation, plan them related to accessibility of residents or pedestrians to the waterfront through those land uses.
7.	Create renewable energy sources on rooftops, degraded terrains, and suitable land area, to become energy self-sufficient and climate resilient and less dependent on the hydro-power stations on the river.
8.	Create pedestrian and bicycle paths along the river, preferably without interruptions. Walking and cycling increases the physical and mental health of citizens.
9.	Reduce roads for cars, trucks and trains as much as possible alongside the river to avoid noise and air pollution.
10.	Designate zones for recreation and cultural and historical sites along this route. Include local NGOs and residents of all ages in this process. The cultural identity will be strengthened.
11.	Make the river banks accessible and create zones of activity for all people with extra attention for people with disabilities.
12.	Create a network and facilitate places for water- and nature-based Eco-friendly recreational activities, like fishing, swimming, rowing, canoing, hiking or bird watching.
13.	Do deeper research on the history of the municipality, including its historical relationship to the river.
14.	Include local stakeholders from different backgrounds in the process of plan development and decision making.
15.	Collaborate with neighboring municipalities to enlarge the positive benefits with reduced or shared costs. Share visions, projects and results in a new to be developed platform of Dnipro river-bank municipalities.


Preserve and regenerate wetlands - a crucial part of the river`s ecosystem
Enhance the biodiversity by adapting the Proposed sites of the Emerald Network
Improve zoning for the nature reserves areas to limit touristic and agricultural activities
FOREST WETLANDS
OPEN WATER
WETLANDS
PEATLANDS


Improve the zoning for natural reserves to limit recreational and agricultural activities in protected areas
Develop infrastructure and services for the River related rectreational and touristic activities
Raise the knowladge about the landscape and the flooded heritage of the Dnipro river
GUSYNTSI
RZHYSCHIV
Develop pedestrian and cycling route along the Dnipro River


Develop connectivity across the Dnipro River in Southern regions
Aply dripping irrigation systems for the agriculture to save water
Implement diverse technologies for green energy production


Provide pedestrian and cycling connectivity across the River
Mantain the balance between green and urbanized embankment to avoid anthropogenic impact on the River`s ecosystem
Use green technologies in industrial production
Regenerate and greenefy former industrial waterfront to give public the acces the River


Reduce industrial waste discharge and heat emissions which affects the river`s eco-system
Improve water exchange between reservoirs to ensure better environment for biodiversity
Implement treatment technologies to improve the water quality
Revitalize the waterfront and abandoned industrial areas for diverse activities

Part 6
City Case Study: Kremenchuk

Contents

Summary

The case study of Kremenchuk highlights a range of issues related to the Dnipro River, encompassing nature reserves and biodiversity, energy and economy, heritage and recreation, water supply, and safety. Through the engagement of municipal authorities and local communities, we gained valuable insights into the local perspective, which we linked to the approaches and strategies discussed in Chapters 4 and 5.

This part explores the historical significance of the Dnipro River and its connection to nature reserves, which is highly valued by residents. It also presents energy modelling to demonstrate the positive impact of green technology on environmental and economic issues. Additionally, the chapter examines the relationship between urban heritage and recreational activities, highlighting the potential for green tourism along the Dnipro River, enhanced by historic landmarks. The issue of flooding threats, provoked by military actions, is also discussed.

This text underscores areas for potential improvement that local stakeholders could collaboratively work on in the future. As a result, it offers suggestions across various thematic fields, integrating them with the impact on the Dnipro River, whose significance for the city's well-being is essential.

Why Kremenchuk?

Preliminary study and overview of the biggest cities along Dnipro River

Initially, an examination of the major cities situated along the Dnipro River was conducted to identify the focal area for closer inspection. This mapping included Kyiv, Cherkasy, Kremenchuk, Dnipro, Kamianske, Zaporizhzhia, Kherson, Nikopol, and Energodar. The primary aim was to ascertain the existence of well-preserved natural environments along the Dnipro River and to determine any potential threats to these areas. Consequently, the maps were designed to highlight the principal nature reserve funds, crucial infrastructure elements such as Hydro-Power Plants, transportation networks including roads and railways, the main industrial clusters and sources of pollution (Figure 4.(1.- 4.)).The main reasons to choose the Kremenchuk city as the case study are described in Table 1.

Figure 1. The biggest cities, located on the Dnipro River. Elaborated by Ro3kvit and Greenpeace CEE

Table 1: Why Kremenchuk city is important to study in connection to the Dnipro River

1.	The unique natural conditions of the Dnipro River are almost not invaded by human activities, apart from the dykes along the waterfront. The nature reserve fund covers a significant stretch of the Dnipro River within the city's administrative borders, which differentiates it from the rest of the cases, emphasizing its recreational and biodiversity valueability.
2.	A notable gap in research and design initiatives in Kremenchuk, in contrast to cities like Dnipro, Zaporizhzhia, Kyiv, and Kherson, where various institutions and development agencies actively contribute to knowledge production. The Ro3kvit coalition is engaged in numerous projects addressing urban environmental challenges arising from the war, yet Kremenchuk remains overlooked in these efforts. This underscores the urgency for conducting preliminary studies and mapping to gain a comprehensive understanding of the local context.
3.	The extensive amount of water pollution was published on the official portal (EcoZagroza) in September-October 2023 and the presence of industries that are considered hazardous for the ecology (Oil Refinery Plant, Thermal Power Plant, Mining and Processing Plants). Given the objective of this report to identify threats to the Dnipro River and explore sustainable management alternatives, there is a critical need to focus on such industrialized urban areas.

Figure 2. Photo of "Register" Cliff and Prydniprovskyi beach
Source: Dasha Korba

Figure 3. Photo of Kriukiv Bridge from the Central Beach of Kremenchuk.
Source: Dasha Korba

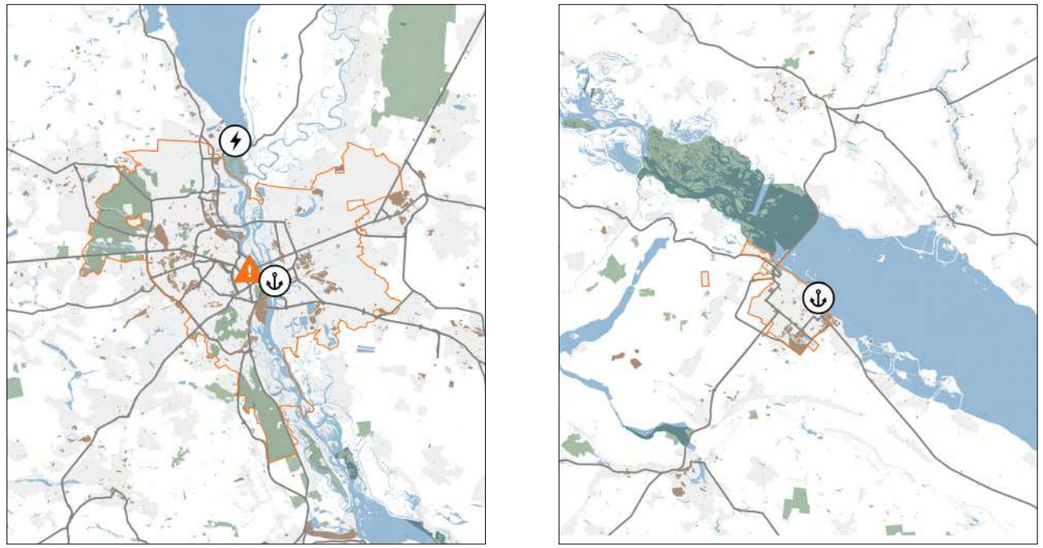


Figure 4.1. Kyiv (left) and Cherkasy (right), Dnipro River, infrastructure and hazardous objects. Elaborated by author based on various open sources.

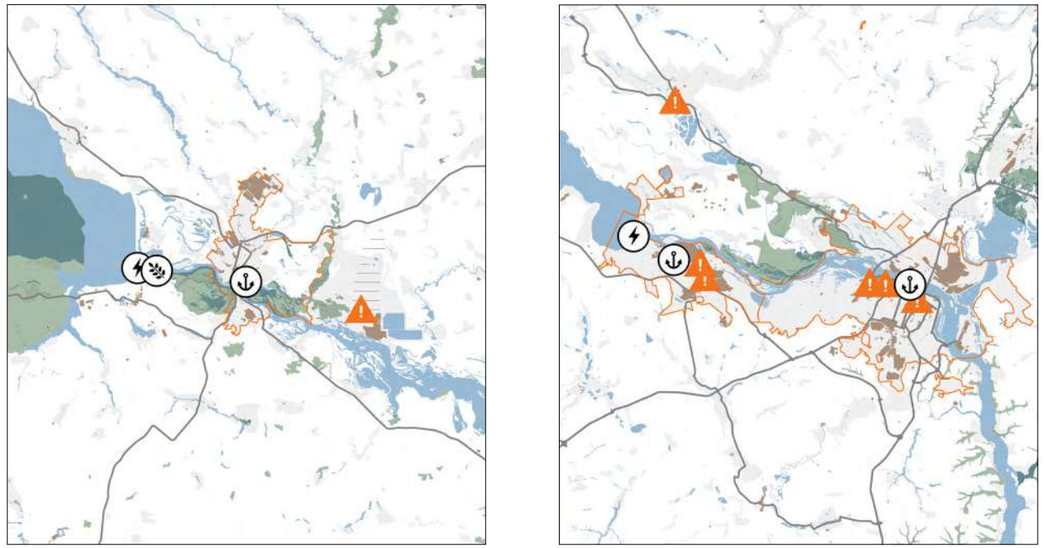


Figure 4.2. Kremenchuk (left), Dnipro and Kamianske (right), Dnipro River, infrastructure and hazardous objects. Elaborated by Ro3kvit and Greenpeace CEE based on various open sources

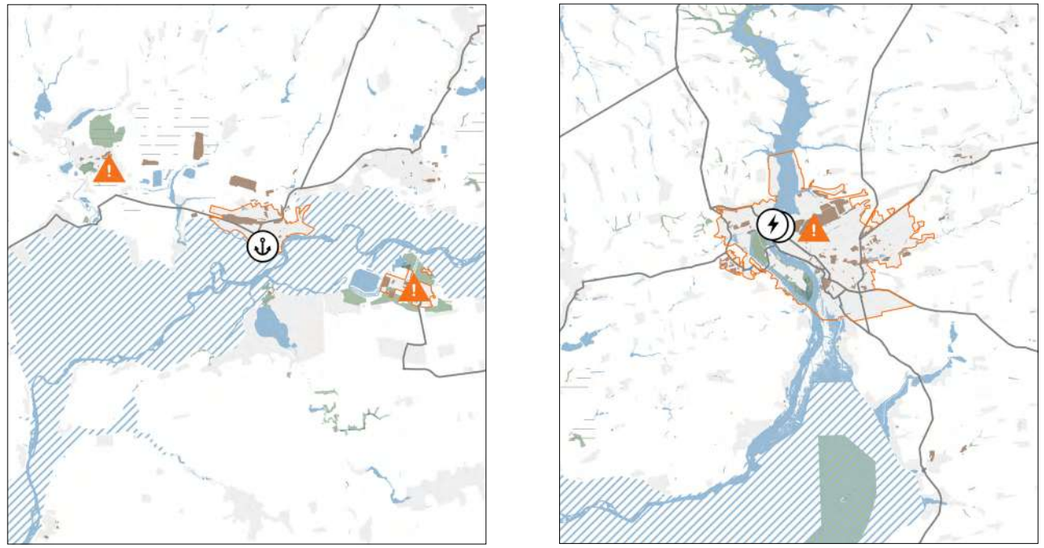


Figure 4.3. Zaporizhzhia (right) and Nikopol and Enerhodar (left), the Dnipro River, key infrastructure and Hazardous objects. Elaborated by Ro3kvit and Greenpeace CEE.

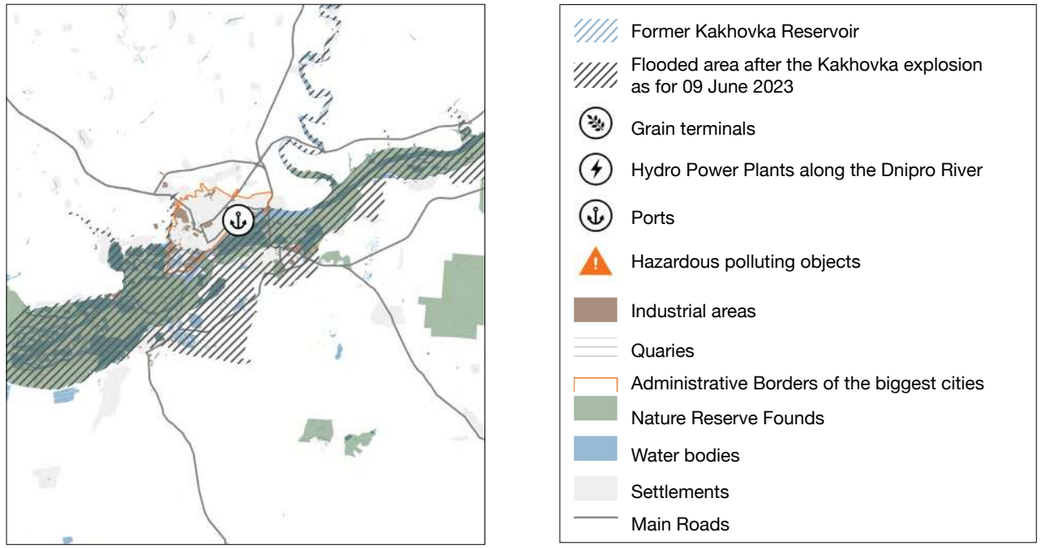


Figure 4.4. Kherson city and flooded area after the Kakhovka explosion Elaborated by Ro3kvit and Greenpeace CEE.

6.1. General context and history of land use

6.1.1. Spatial historic development of Kremenchuk city

The evolution of Kremenchuk city was significantly shaped by the transport capabilities of the Dnipro River and its rural environment. Historical records first acknowledge Kremenchuk in 1471, portraying it as a fortified military settlement. The city was a pivotal junction for the ancient “Chumatskyi Shlyah” route (Romodanovsky), facilitating its emergence as a bustling trade hub due to its proximity to the Dnipro`s rapids, which hindered further riverine transport of heavy goods.

In 1635, French military engineer Guillaume Le Vasseur de Beauplan, renowned for his “Description of Ukraine,” sketched the Kremenchuk fortress layout on-site. The era spanning from 1571 to 1764 is often referred to as Kremenchuk’s Cossack era, a time when Cossacks dominated the demographic landscape of the Kremenchuk area, from the ancient Cherkasy starosta era through to the Hetmanate’s territorial regiments era in Chyhyryn, Myrhorod, Lubny, and Poltava.

Kremenchuk caught the attention of the Russian regular army amidst the colonization efforts on the Right Bank. By 1764, the city transitioned from Cossack Hetmanate governance, becoming the administrative hub of the Novorossiysk province. A turning point in the city’s growth trajectory was marked by the construction of the Kryukiv bridge in 1873, alongside establishing its first mechanical engineering factory, facilitating the transit of trains through Kremenchuk.

Figure 1. Bridge in Kremenchuk, 1941
Source: fund of the Kremenchuk Museum of Local Lore

Figure 4.1. illustrates the surge in infrastructural facilities and industrial enterprises towards the late 19th century. Mechanical engineering and metalworking became prominent sectors, notably at the Krukiv machine-building factory on the right bank and the Kremenchuk Road Machines Plant on the left bank of the river.

Kremenchuk urban fabric expanded from a historic center to an industrial powerhouse in the Soviet Ukraine, attracting various manufacturers to both the inner city and surrounding rural areas. Figure 4.2 depicts the situation in 1930 when the railway network expanded to peripheral areas to accommodate the industries and emerging micro-districts like “Pershyi Zanasyp”, “Druhyi Zanasyp”, and “Cherednyachky” which were suffering from flooding until the construction of dykes in 1917.

By the end of the 19th century, Kremenchuk, with its orderly urban grid and diverse population (in 1897: Jews 46.95%, Ukrainians 30.12%, Russians 19.25%, Polish 1.74%, Germans 0.69%, Tatars 0.42%) (Lushakova, 2006), stood as a distinct urban entity amidst Ukrainian peasant settlements. The blurred line between urban and rural areas became evident as villagers sought employment in urban factories. The city’s expansion was closely tied to the railway, transforming former villages into mixed-use areas incorporating industrial zones and “microrayons”.

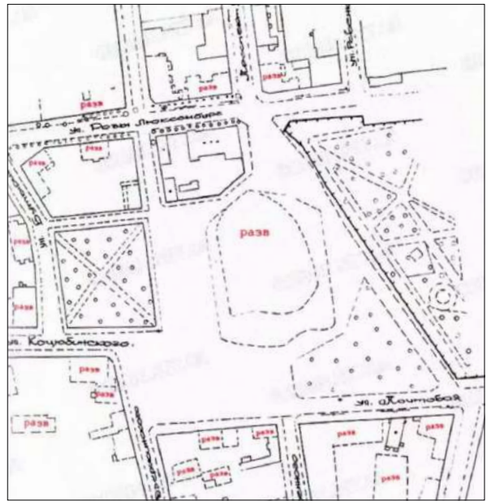


Figure 2. Excerpt from the Kremenchuk Master Plan, 1954
Source: okrain.net.ua, Fund of the Kremenchuk Museum of Local Lore

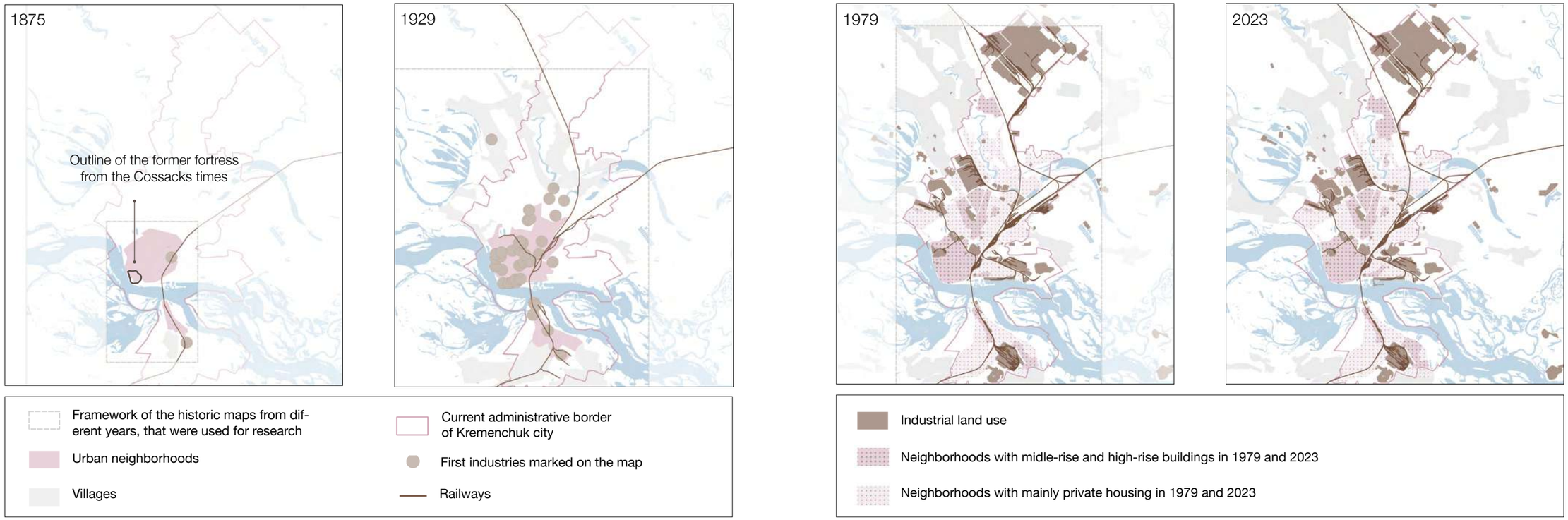
Figure 3. Surviving buildings after the liberation of Kremenchuh. Source: okrain.net.ua, Author Potaneko P.S.

On the brink of World War II, Kremenchuk was a hub of industrial activity. The city suffered extensive damage (90% of the historic center was destroyed) (Figure 3) and was occupied by Nazi forces in 1941. Before the occupation, numerous industrial facilities were relocated to other cities within the Soviet Union. The post-war recovery involved a certain level of community participation in rebuilding efforts. Interestingly, industries once located in the city center were moved to the outskirts, spurring suburban growth and the integration of adjacent villages into the city. The former industrial waterfront gave way to “Yuvileyinyi Park” and a public beach. This case should serve as a local example for other Ukrainian cities as the socially and environmentally oriented reconstruction of the waterfront. However, the post-war developments also included the construction of a Hydro Power Plant and a Thermal Power Plant near the city, whose economic impact will be described in the following chapters.

Figure 4.3, based on a 1979 map, showcases the extensive industrial development and consequent residential expansion. This period saw the mechanical engineering and metalworking sectors flourish, notably with the “KrAZ” factory and other smaller enterprises in the city’s North-West. Settlements like “Novoivanivka” were urbanized due to industrial proximity. The construction and building materials industry, particularly in the eastern part near the “Pershyi Zanasyp” district, became significant, leading to the initiation of granite and sand quarries.

Architectural historian Alla Lushkova notes that Kremenchuk’s most prosperous development phase occurred between the 1960s and 1980s, with the city area and population both seeing substantial increases. This growth was tied to the Oil refinery cluster, Carbon black plant, Reinforced concrete sleeper plant, Steel plant, Construction building plant, and Dnipro sand mining and processing plant. The oil refinery cluster, depicted in Figure 4.3, prompted the construction of two residential districts (“Blyzhnii Molodizhnyi” and “Dalnii Molodizhnyi”). Industrial enterprises primarily funded the development of social infrastructure. The construction of the Kremenchuk Museum of History and Ethnography, along with numerous schools, was financed through industrial contributions (Kremenchuk Telegraf, 2016).

Today, the district of the historic center adjacent to the waterfront and the Molodizhnyi districts are regarded as the most desirable living areas in Kremenchuk acording to the local media (Kremenchuk Telegraf, 2013).



Figures 4.1., 4.2., 4.3 and 4.4.: Urban development of the Kremenchuk city.
Author: Elaborated by Ro3kvit and Greenpeace CEE based on the historic maps and open data sources.

6.2. SWOT analysis

Strengths, Weaknesses, Opportunities and Threats related to the Dnipro River in Kremenchuk

The Dnipro River plays a significant role in the city. The team developed a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis covering different aspects of the Dnipro River in Kremenchuk. Some points were executed from the Development Strategy, while others are based on the city overview and personal communication with the municipality representatives during the visit.

The key strong aspects are the significant natural preserved areas, the landscape reserves Biletski Plavni, Kremenchuk Plavni and recreational areas along the Kamianske reservoir on the left bank. Indeed the nature reserve conditions are unique and should be very well protected. However, such weaknesses as insufficient development and improvement of the recreational areas (pointed out in the Strategy Document) can significantly deteriorate the urban planning achievements and landscaping of Kremenchuk city.

Even though there is not that much funding available and in general the topic of recreation and tourism are not a priority in the war-time conditions, local authorities see the opportunity and importance in the creation of recreational and tourism development strategies.

Another strength is the large amount of surface water not only of the Dnipro River but also of the Psiol, Sukhyi Kahamlyk, Kryva Ruda, and Omlyk Rivers. However, the discharge of the untreated rainwater from the city goes to the small rivers, and tributaries of the Dnipro, with unsatisfactory conditions of the sewerage system, equipment, and pipelines. There are significant problems with the siltation and overgrowth of the riverbeds of the Sukhyi Kahamlyk and Kryva Ruda rivers. Consequently, the water quality in the Kamianske reservoi doesn`t meet the standard. It is also proved by the indicators of the oxygen in the water monitoring points provided by the governmental service Eco Zagroza. Currently, there is an opportunity to solve the water treatment quality in cooperation with the Sweco group, helping Kremenchuk to improve the water supply system for drinking water intake, water purification, monitoring of quality and process automation systems (Sweco)

Unfortunately, there are big threats to the Dnipro River in the ongoing war, also the yearly rising groundwater levels and flooding of the territory bring a lot of damage. However, the municipality also envisions the opportunity to bring the artificial reservoir system as close to the natural one as possible, which sets an important direction for water management.

Another big threat to the river is related to industrial wastewater, where the concentration of the pollutants exceeds the norms. The non-equipped landfills are also hazardous for groundwater pollution with large volumes of industrial and household waste. Therefore the reduction of the anthropogenic impact should be one of the main priorities for the city.

Another issue is related to the energy-production sector, which includes the Hydro Powerplants grids of the Dnipro River. According to the local authorities of Kremenchuk, the green energy strategy should bring independence for the municipal sector from the monopoly position of energy supply organizations. Therefore Greenpeace and Ro3kvit envision great potential in the introduction of such a decentralized system of renewable energy sources.

Strengths	• Significant natural preserved area • The presence of a landscape reserve of national importance - Biletski Plavni • A recreational area along the Kamianske reservoir on the left bank of the Dnipro River • Surface waters are represented by the Dnipro River, Kamianske Reservoir, Psiol, Sukhyi Kahamlyk, Kryva Ruda, Omlyk rivers, a pond in the city park
Weaknesses	• Dependence of the municipal energy sector on the monopoly position of energy supply organisations • Insufficient development and improvement of the recreational area along watercourses • Location of a number of industries in the coastal protection zone of the reservoir that are incompatible with the regime of water protection areas • Rising groundwater levels and flooding of the territory • Significant volumes of industrial wastewater - concentrations of pollutants in surface runoff exceed the MAC • The landfill is not equipped, there is no protection against groundwater pollution - large volumes of industrial and household waste • Siltation and overgrowth of the riverbeds of the Sukhyi Kahamlyk and Kryva Ruda rivers • Unsatisfactory condition of the sewerage system, equipment, pipelines, discharges of untreated rainwater from the city into small rivers, lack of centralised stormwater drainage • Non-compliance of water quality in the Kremenchuk reservoir with the standards • Loss of water from water supply networks due to their depreciation - overestimation of the levels of drainage structures, their siltation • The water treatment system does not ensure that the water meets the State Standard 2874-82 “Drinking Water” • Large industrial and warehouse areas that are not used or are used inefficiently
Opportunities	• Create the green energy strategy for the city • Improve recreational areas along the Dnipro River • Replace drainage system with the advanced one • Bring the artificially created reservoir system as close as possible to the natural ecosystem • Reduce the anthropogenic load on the city’s territory and increase water exchange in the Kamianske reservoir and Kremenchuk reservoir • Use efficient filtration system to achive drinking water standart • Reuse industrial wastelands along the river
Threats	• Lack of investment for green energy • Lack of budget for cultural and recreational development due to the continuity of war • Unpredictable changes in ecosystems of the rivers due to the war actions

Interviewing
Kseniia Opria

24 years old
Lives in Kyiv

I have been living in Kyiv for 8 years now, but I was born in Kremenchuk, where I spent my childhood and teenage years.

My first memory of the Dnipro River is of its pebbles. There used to be a part of the bank that was always a sandy beach, but if you went towards Prydniprovskyi Park, there was an area where the beach turned into a thin strip of pebbles. As a child, it was a fun challenge to walk across them without getting our shoes wet. We would treasure hunt in the shallow water. I vividly remember going to the beach with my parents when it was crowded. We spread out our towels to sunbathe on the sand like everyone else. We watched the trains and cars passing over the bridge, and when big cargo ships went by, they made these amazing big waves.

Whenever we drove across the Kriukivskyi Bridge over the Dnipro, we could see bizarre-shaped boulders overgrown with trees and bushes. As a child, I was fascinated by them. My parents said they were parts of the foundation of an old bridge destroyed during the Nazi occupation in the 40s. The story sounded like a fairy tale to me. I was amazed that my city used to have a bridge that turned into boulders sticking out of the water, home to greenery, like something out of a legend.

There is also a section of the Dnipro River that runs behind Prydniprovskyi Park, closer to the *Four Seasons* restaurant. That part of the river still has those pebbles from my childhood, and it's a beautiful, romantic place, especially in the warm season when you can sit on the beach. The water there is always calm, and the trees create a lovely shade. When I was a student, it was my getaway, a place to escape and listen to the sound of the water. Nowadays, the place can be a bit crowded because people like to go there for picnics and barbecues, but back then it was a secluded spot.

Now, the river is a great place to visit any time of the year when I visit my family in Kremenchuk. It's the highlight of the city, where you can bring your friends and show them the beautiful embankment.

As a child, I thought everyone had such a big river in their city because I couldn't imagine it otherwise. Even after moving to Kyiv, I still ended up near the Dnipro. But whenever I took friends from other cities on a tour of my childhood spots, they were always in awe.

In Kremenchuk, it's easier to access the river directly and walk right near the water. I never thought of the Dnipro as a river for swimming because it is so deep and chaotic. I think it's better suited for walks along the promenade and for resting your eyes on the distance, especially if you're in a melancholic mood and need to soothe your mind. People come there to fish, sit on the shore, or sunbathe in the summer, but not so much to swim.

Kremenchuk is an industrial city, where the priority is profit, so environmental issues are unfortunately not a focus. I guess that if there is even more industry using the river for its needs, the conditions for the Dnipro will get worse. There are also problems with using its water for domestic purposes. People dump their garbage there, especially non-degradable trash, which doesn't get cleaned properly. This can't be good.

I wish the river were cleaner because when you sit on the bank for a long time in Kyiv or Kremenchuk, you see bottles, plastic bags, and strange household items washed up. During certain periods in the summer, you get warnings that the water isn't safe for swimming because of some kind of infection. People have always ignored these warnings and continued to swim; ideally, this should be more controlled. There is also a period when the Dnipro blooms, causing unpleasant smells. This seems to be the case all over Ukraine. So we need to clean the river and educate people. If cleaning it isn't possible, then maybe we need to let it live its own life for a while, without exploiting it, so it can self-heal.

6.3. Kremenchuk waterfront

6.3.1. Current land use of the waterfront

Primarily distinguished as an industrial city, Kremenchuk also offers a surprisingly good public linkage to its waterfront. The eastern part of the waterfront within the city is occupied by the port facilities, while the city center has a green public waterfront. Additionally, the Kriukiv district, located on the river's right bank, is characterized by its predominantly unurbanized riverside spaces, with portions included in the Kremenchuk Plavni Regional Landscape Park (Figure 1).

For a better understanding of the activities on the waterfront, the classified land-use analysis of the areas with a buffer of 350 meters from the waterline is visualized with Figure 2 and 3. The greenery (wood - 54.13 % and park - 7.30%) occupies the biggest surface. There is also a noticable areas of beaches (6.26%). Furthermore, the area of the Abandoned Elevator industrial zone along the western stretch of the waterfront was redeveloped into a residential area, which has good public access to the river.

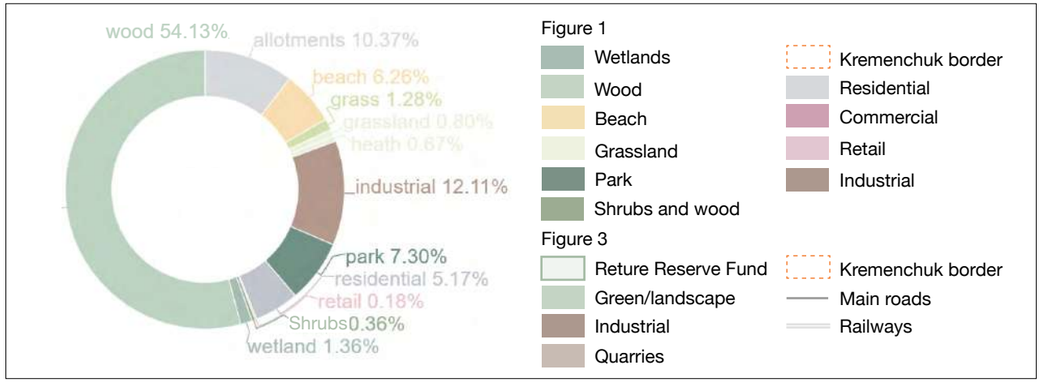


Figure 2. Proportion of the land use categories in Kremenchuk city within the 350 meters buffer from the riverfront
Elaborated by Ro3kvit and Greenpeace CEE

Figure 1. Green and industrial areas in close to the riverfront in Kremenchuk
Elaborated by Ro3kvit and Greenpeace CEE based on the open sources and planning documentation of Kremenchuk city

0 1 2 km

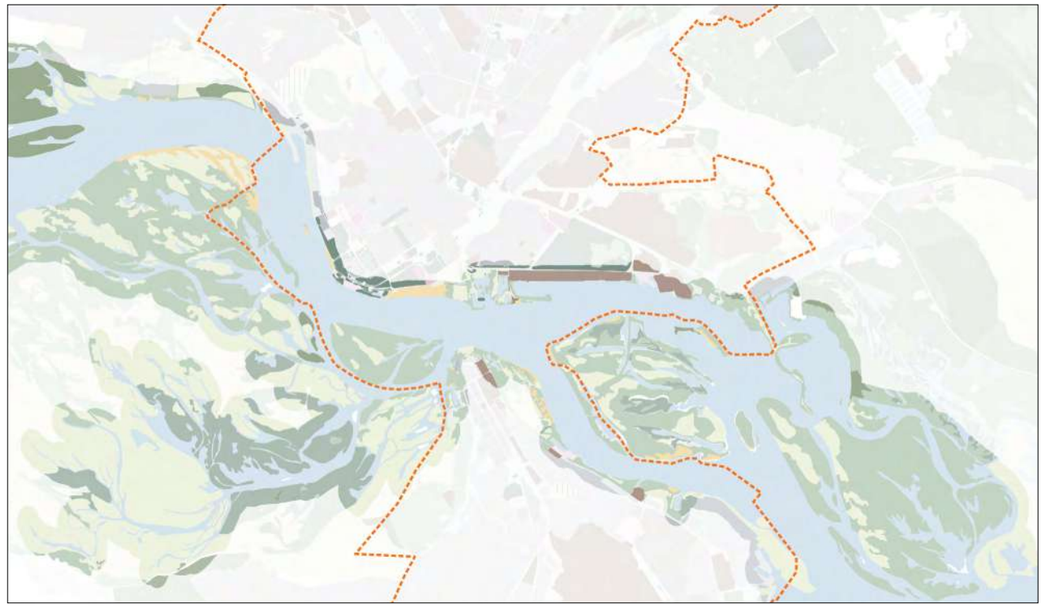


Figure 3. Landuse of the area within 350 meters buffer from the riverfront
Elaborated by Ro3kvit and Greenpeace CEE based on the open sources and planning documentation of Kremenchuk city

0 1 2 km

The pictures of the main areas of the interaction with the river are shown in Figures 5 and 6. They can be grouped by types of activities:

- Transitional: the promenade along the dyke.
- Recreational and observational: beaches, fishing spots, “Chill” area
- Landmarks: the Granite reference point, the River Port building
- Areas with boats: Poseidon Club, Delfin station, Yacht Club Santorini
- Kremenchuk city border

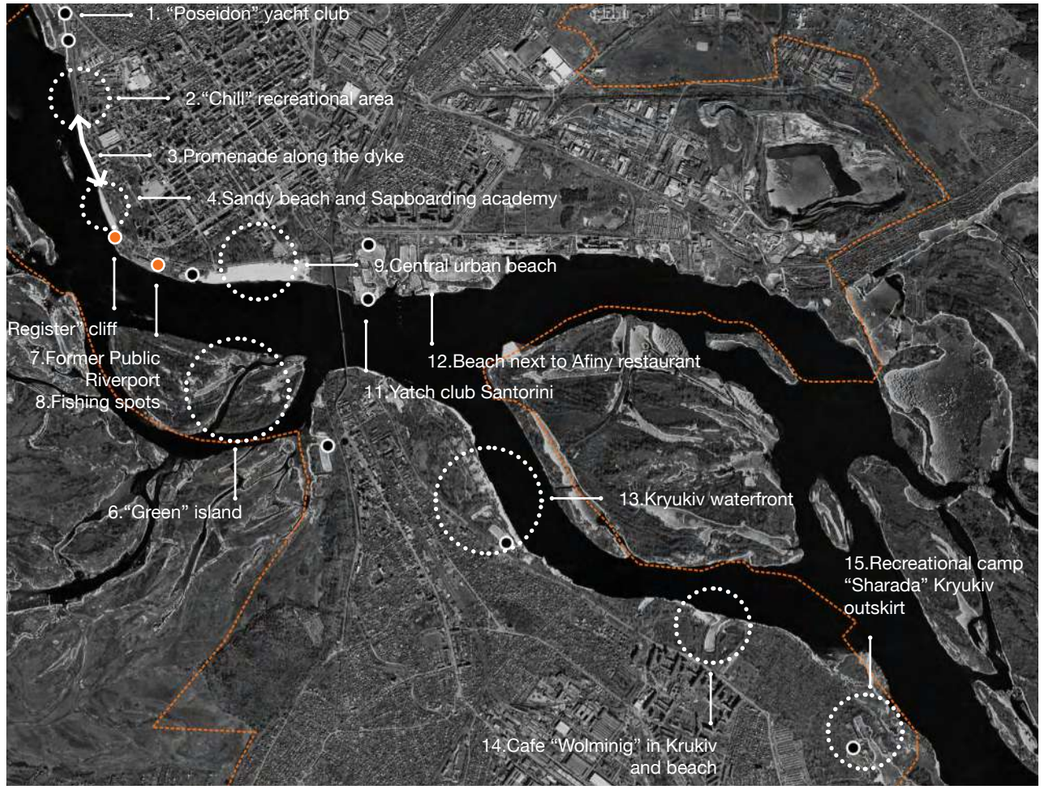


Figure 4. Key points of interest along the Kremenchuk riverfron
Elaborated by Ro3kvit and Greenpeace CEE based on the open sources

1. “Poseidon” yacht club

2. “Chill” recreational area

3. Promenade along dyke

4. Sandy beach and Sapboarding

5. “Register” cliff

6. “Green” island

7. Former Public Riverport. Currently Privatbank

8. Fishing spots next to the riverport

9. Central urban beach

Figure 5. Photos of the key points of interest along the Kremenchuk riverfront
Sources: Fulco Treffers, Dasha Korba and Google Street View

6.3.2. Current accessibility of the waterfront and potential for improvement

According to the proximity analysis conducted with GIS, almost the whole waterline is accessible within the pedestrian walk (Figure 7). The only area that has issues in terms of connectivity is under the bridge. It is not maintained and has a lack of pedestrian paths due to certain restrictions that were valid also before the war. Therefore the continuity of the public waterfront is interrupted and the best alternative to access the eastern part of the city is along the Ukrainska and Velyka Naberezhna streets. To summarise, the city has an excellent connection to the water. According to the planning scheme of the Kremenchuk from 2020 (Figure 8), the existing unmaintained areas along the Dnipro River will be rearranged for public use: sports and recreational functions such as aquapark, cafes, and restaurants. However, the areas under the bridges interrupt the pedestrian passages and connectivity with the waterfront.

10. Restricted area under the bridge

11. Yacht club Santorini

12. Beach next to Afiny restaurant

13. Kriukiv waterfront

14. Cafe “On the water”, Kriukiv

15. Recr. camp “Sharada”, Kriukiv

Figure 6. Photos of the key points of interest along the Kremenchuk riverfront
Sources: Fulco Treffers, Dasha Korba and Google Street View

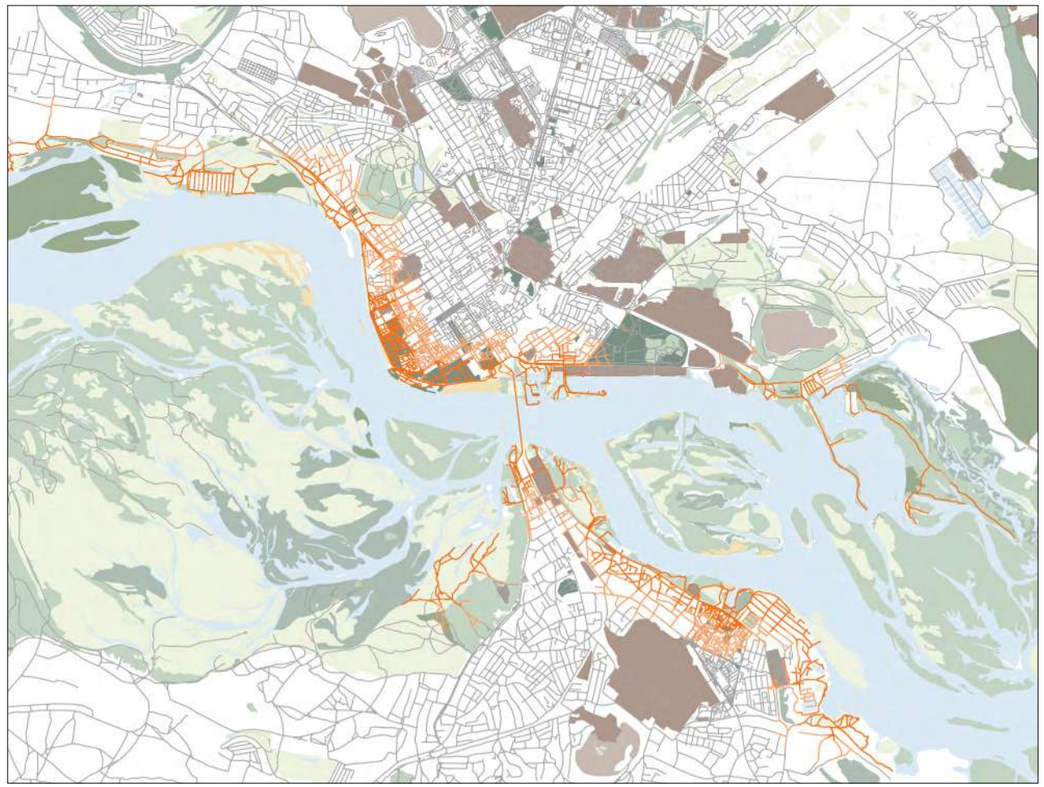


Figure 7. Proximity to the accessable riverfront in Kremenchuk (400-800 meters)
Elaborated by Ro3kvit and Greenpeace CEE based on the open sources and planning documentation

Some suggestions for improvment are provided in Table 2.

Table 2: Suggestion for the waterfront accessability improvement

1. Considering the approved construction of the second bridge, the Embankment of the Leitenant Dniprov will get more vehicle traffic, especially next to Makarova Street (Figure 8). However, this threat can become an opportunity for different pedestrian experiences of crossing the road within the pedestrian bridge or maintaining the “wastelands” under the bridge for public access. This kind of land use is present in other cities, proving that the space under the bridge shouldn`t be excluded from public use. A bright example is Poniatówka area in Warsaw, which provides not only pedestrian access, but also recreational activities on the beach (Figure 9).
2. If the space under the bridge can be included to the public use, it will be perceived as a safe and pleasent place. The area under the bridge on Asiatisk Pl. in Kopenhagen, Denmark, which is included into the urban activities within the furniture and other urban design solution is also a good example. (Figure 10). For sure, this kind of access can be provided only in peaceful conditions due to security issues.
3. A similar problem of the interrupted connectivity under the Kriukiv bridge (Figure 8) is currently present on the left bank of the river. Considering the master plan`s anticipation of the development of recreational areas between the two bridges, it is crucial to review the existing restrictions in the detailed plan of the territory to take the necessary safety measures and provide a pedestrian connection there.

Figure 8. Extraction from the planning documentation showing the planned bridge (2020) Source: Data.gov.ua

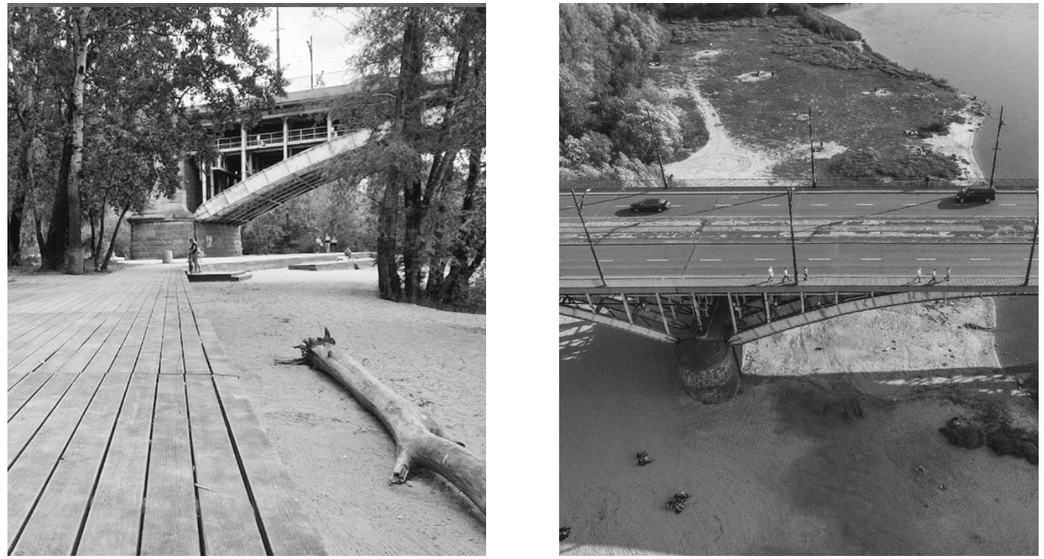


Figure 9. Poniatówka area under the bridge in Warsaw, Poland.
Source: Google Street View

Figure 10. Pedestrian and cycling passage under the bridge in Copenhagen, Denmark.
Source: Svitlana Usychenko

6.4. Nature reserves and local engagement

Existing qualities.
Nature reserve system and biodiversity

Within the city, there are seven nature reserve fund sites, including one of national importance – the Biletski Plavni (”Biletski Plains”) reserve (part of the regional landscape park Kremenchuk Plavni (”Kremenchuk Plains”). The total area of the nature reserve fund sites within the city is 682.329 hectares, accounting for 7.12% of the city’s area.

As was mentioned before, the area next to Kremenchuk City has a unique character of the natural Dnipro River conditions, which should be protected from harmful anthropogenic activities. These areas obtained the preserved status due to the civil society action in the 1990s. Okrain.net published the historical text (Nikiforov V., Muzychenko N., and Symonenko N.) that describes events from that period. Despite the water legislation, the city executive committee’s architectural department planned to use 30 hectares of floodplain lands for the development of residential district № 17-17A, against legal regulations. This plan sparked outrage among the local community, leading to a series of protest actions: picketing, organizing rallies, and collecting signatures for a protest letter. On June 5, 1991, Environment Protection Day, a rally took place at Victory Square in front of the administrative building to defend the Biletski Plains. The movement demonstrated the bright ability of Kremenchuk residents to be conscious in protection of natural heritage. Consequently, the city council implemented environment protective measures for the area.
The collaborative effort between the Ministry of Environmental Protection of Ukraine, the National Academy of Sciences of Ukraine and Poltava scientists for the site investigations of Biletski Plavni resulted in the granting of the status of a landscape reserve of national impor-

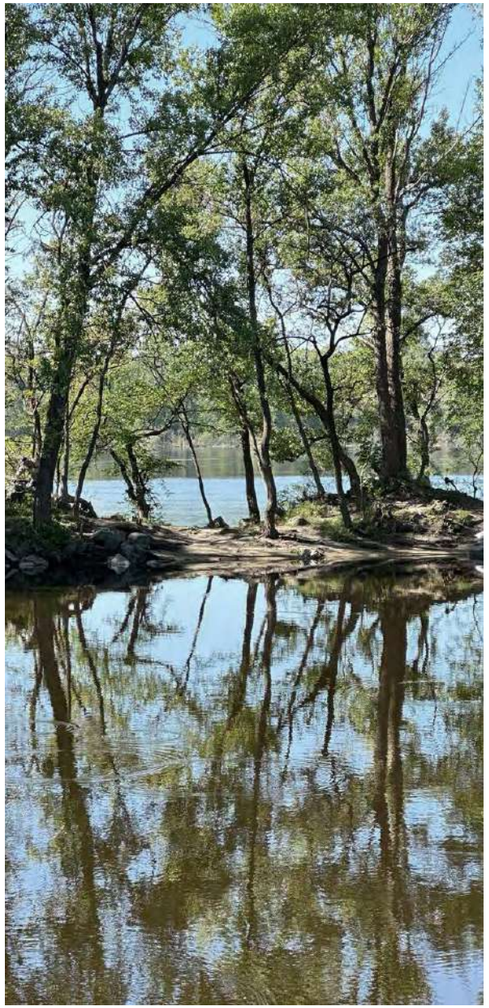


Figure 1. Photo of the area next to the central beach of Kremenchuk
Source: Dasha Korba

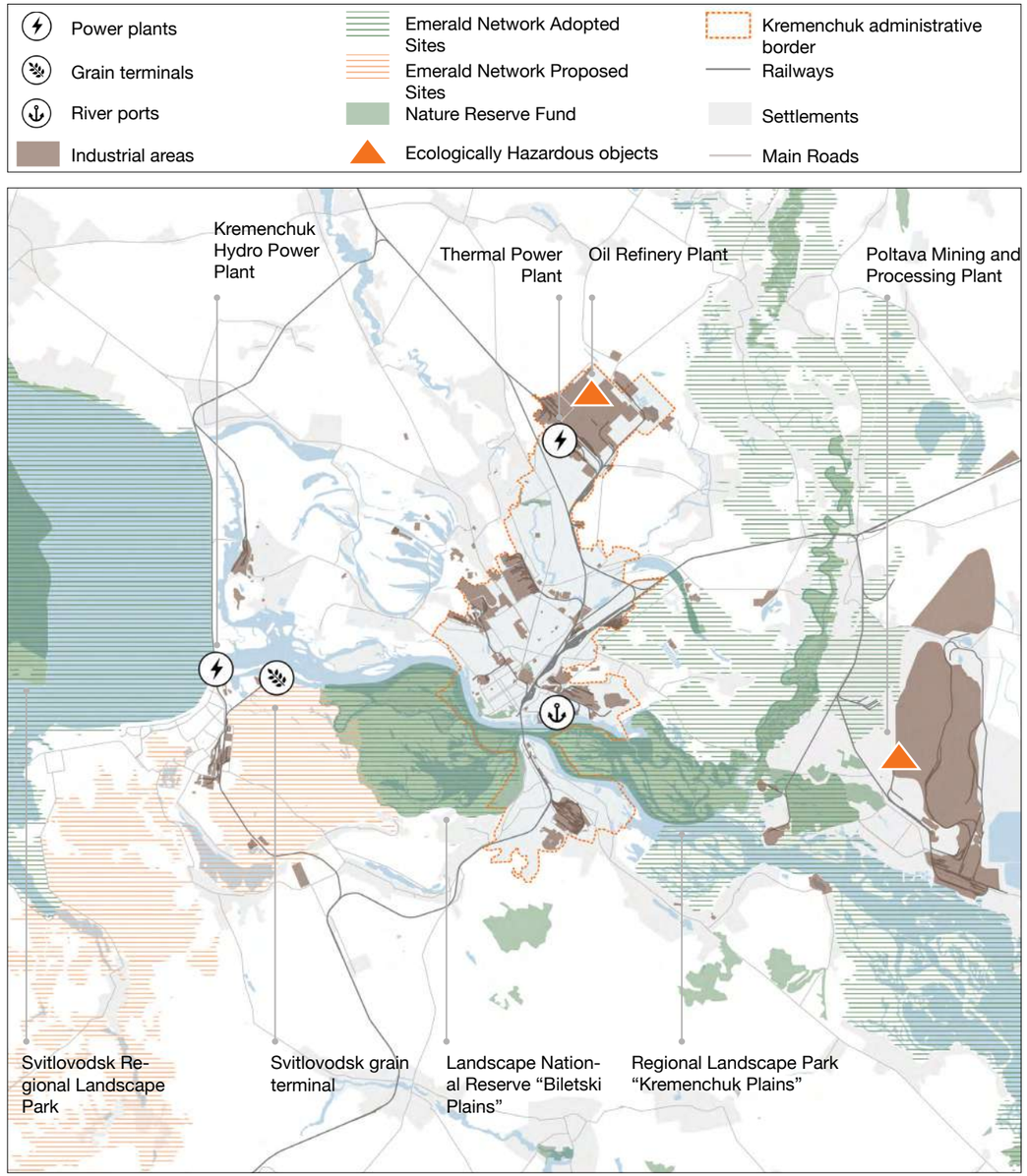


Figure 2. Natural reserves and ecologicaly hazardous objects
Elaborated by Ro3kvit and Greenpeace CEE based on diverse data sources

tance in 1994 p. The creation of the Regional Landscape Park “Kremenchuk Plavni” was approved in 2001 by Poltava regional council.

It should be noted that the status of Regional Landscape Park aims not only to preserve the area from anthropogenic impact but also to provide a recreational green zone. Therefore green tourist activities and recreation are allowed in these areas. However, it is crucial to keep the balance and to raise awareness of the rules of behavior in the landscape park.

6.4.2. Suggestions Potential for improvement

Considering the unique conditions of the Kremenchuk Plavni and the hydrological environment of the upper part of the Kamianske reservoir, it is important to implement the differentiation for the recreational, sanctuary and preserved areas. The park is a sanctuary for a diverse array of flora and fauna, including over 50 rare species listed in the IUCN Red List, the European Red List, the Red Book of Ukraine, and the Regional List. In 2009 there was a plan to assign to the Kremenchuk Plains the status of the National Landscape Park. It would activate more scientific activities regarding biodiversity and its preservation.

Figure 3. Photo of the central beach in Kremenchuk city with the view to the Kremenchuk Plains Landscape Park.
Source: Dasha Korba

As can be seen from the map (Figure 2), the preserved areas of Kremenchuk Regional Landscape Park and Svitlovodskyi Regional Landscape Park are not connected. However, the Adopted and the Proposed sites of the Emerald Network which make the expansion of the Svitlovodskyi Park create a certain connectivity and green corridors at the regional level. Therefore adoption of the proposed Emerald Network sites and implementation of the laws for the limitation of agricultural activities in this area will help to preserve and enhance the unique biodiversity of the site.

The case of Kremenchuk proves the relevance of the defined suggestions in Chapter 4 on the city scale. The Biletsky and Kremenchuk Plavni reserves are very important parts of the Dnipro River. There are very little non-transformed areas along the Dnipro cascade, which are mainly preserved in the upper parts of reservoirs. However both statuses (Regional landscape park and Nature reserve) don`t limit human activities on the sites, moreover, uncontrolled tourist activities can affect the natural environment. Therefore, it is important to work with the landscape park zoning typology to ensure different activities concerning nature. For example, some parts of the Nature Reserve Biletsky Plavni can be converted to a Nature Sanctuary as it happened with the “Dniprovsko-Orilskyy” Natural Sanctuary.

Another option is to have certain zoning of activities in the planning documentation: scientific research areas with the forbidden agricultural activities, recreational areas with the minimum interventions (green touristic hiking routes), and recreational areas with medium interventions (camps, pit-stops, cycling routes). The case of Zaporizhzhia Landscape Park Khortytsia is an example of such variable zoning with limitations for certain activities.

Terminology used

- Nature reserve (Zakaznyk, Заказник) - Natural territories (water areas) are declared as nature reserves for the purpose of preserving and restoring natural complexes or their individual components. On the territories of reserves, it is prohibited to cut down forests of the main use, clear-cutting, thinning, reforestation and gradual felling, removal of clutter, as well as hunting and other activities that contradict the goals and objectives set out in the regulation on the reserve (Verkhovna Rada of Ukraine)
- Regional landscape park (Regionalnyi Landshaftnyi Park, Регіональний ландшафтний парк) - environmental and recreational institutions of local or regional significance created to preserve typical or unique natural complexes and objects in their natural state, as well as to provide conditions for organized recreation (Verkhovna Rada of Ukraine)
- National natural parks (Natsionalnyi Pryrodnyi Park, Національний природній парки) - National nature parks are nature protection, recreational, cultural, educational, scientific and research institutions of national importance that are created to preserve, restore and effectively use natural complexes and objects of special environmental, health, historical, cultural, scientific, educational and aesthetic value (Verkhovna Rada of Ukraine)

Interviewing
Nazarii Lisnyi

Creative strategist
28 years old

I am a brand strategist and cultural event organizer based in my hometown of Kremenchuk, Ukraine. Born and raised here, I studied geography in Kyiv but returned to Kremenchuk nearly two years ago when the full-scale invasion began.

The Dnipro River has always been a significant part of my life, connecting the two cities where I've lived and studied. It symbolizes home and brings me a sense of calm and comfort through its sights and sounds.

Since returning to Kremenchuk, I frequently visit the river, walking along the promenade and central beach, listening to nature and the flowing water, which helps me find harmony and appreciate the river's power and majesty.

My earliest vivid memory of the Dnipro dates back to when I was about four years old. While playing on the beach near our family's small dacha, I dug pits in the sand, waiting for water to fill them before adding earth and branches to create mud. When one of my pits collapsed and the mud flowed into the river, I became frightened, imagining that my mother would become ill from drinking the polluted water. I deeply regretted contaminating the river.

After returning to Kremenchuk, my like-minded friends and I decided to organize cultural events for the city's young people. On July 2, we held a large festival of Kremenchuk culture in Prydniprovskyi Park, with eight activity zones. During a break in the program, the organizational team and some lecturers spontaneously went for a swim in the Dnipro, just fifty meters from the festival site. The moment was filled with absolute summer bliss, surrounded by vibrant Ukrainian culture and beautiful young people, with the cool, clean river water refreshing us.

Another memorable Dnipro experience involved taking American singer Emperor X to Mount Pyvyha, a popular vacation spot near the Kremenchuk Sea reservoir, after his charity concert in our city. As we approached the mountain, he was astounded by the sound of the waves and the impressive sight from the top. In a later interview, he rated all the cities he visited during his Ukraine tour as 5 stars, but gave Kremenchuk 5 stars plus, inspired by both the natural beauty and our hospitality.

During my first hydrology lecture at university, our professor surprised us by stating that the body of water flowing through Kyiv is not actually the Dnipro River, but rather the upper part of the Kaniv Reservoir, part of a cascade of reservoirs. This is why I now consider the Kremenchuk Reservoir to be part of the Dnipro, despite expert disagreement.

I visit the river at least once a week, and sometimes daily when the weather is good, to take a break, reboot, and relax in the quiet surroundings.

To ensure the Dnipro's future, we must first address the ecological issues affecting water quality and safety. The river's algal blooms are exacerbated by phosphates from detergents in sewage and the impact of global warming.

Information campaigns and stricter regulations on phosphate-containing detergents are needed, particularly in cities like Kremenchuk that are located directly on the Dnipro. However, current efforts by environmental organizations are insufficient, and a change in approach is necessary.

Once the war is over, the Dnipro's recreational potential should be developed, with the establishment of tourist transport routes and the revival of passenger water transport. Kremenchuk's Soviet-era infrastructure, such as the large park and central beach, holds great promise for private businesses to create a thriving tourist area.

However, regulations must ensure that access remains open to the public and prevents illegal construction on the embankments. Ultimately, the state and our personal consciousness should be the key to preserving the majestic Dnipro as portrayed in classical literature and art, rather than an obstacle to its protection and enjoyment.

6.5. Flooding and security

6.5.1. Existing qualities and limitations

Historically flooding was one of the biggest problems for Kremenchuk city. Documents mentioned significant floodings in 1769, 1797, 1820, and 1845 (Hnadysh I. Roy I., 2013).

After regular floodings of 1907, 1916 and an especially damaging one in 1917 the reinforcing project for the dyke for the central area of the city was developed. The construction was finished in September 1929 (Sokolova I.), however, in 1931 there was the largest unpredictable flooding (Figure 1), when out of 6300 total buildings 1450 were destroyed and 3350 were half-destroyed (Kremenchuk Telegraph). The dyke was damaged and reconstructed in the 1930s. After the creation of the Kremenchuk Reservoir and the Kremenchuk Dam construction in 1959 the level of water in the upper part of the Kamianske reservoir next to Kremenchuk City became controllable as well as the problem of flooding.

6.5.2. Strategic directions for improvement

Nowadays Kremnchuk city again meets the flooding threat. It is mentioned in the Kremenchuk Development Strategy 2017. The recent flooding in April 2023 (Figure 3) revealed the complexity of this problem. According to ecologist and scientist Maksym Soroka, several issues provoked the flooding: significant rainfall in the north, targeted actions by Ukrhydroenergo, and illegal development along the Dnipro's shores (Kremenchuk Telegraf, 2023).

Table 3 shows, how the problem of flooding should be addressed. Unlike in many other places, the priority will be given to the governance of the water supply and discharge, water exchange, cleaning procedures and riverfronts protection policies enforcement monitoring rather than within the creation of physical protection, such as dykes. Kremenchuk Development Strategy doesn`t consider the flooding protection actions on the regional level as corresponding to the strategic goals of the energy-efficient and ecologically safe city, however, these topics are closely interconnected and should be integrated within the strategy and further projects.

Table 3. The main actions that should be taken to reduce the flooding threat are the following:

1. Improvement of the water exchange in the Kamianske reservoir, with the increase of the water exchange intensity inside of the water reservoir and between the reservoirs, which can significantly improve the quality of water.
2. The estimation of the flooding control should be also considered during the decision-making for the renovation of the water supply and water discharge system.
3. Reduction of the anthropogenic load on the waterfront areas within the control of illegal construction in the waterfront protected zones.
4. Address the problem of the tributaries' siltations and overgrowth of the riverbeds (Sukhyi Kahamlyk and Kryva Ruda), which also increase the level of seasonal flooding.

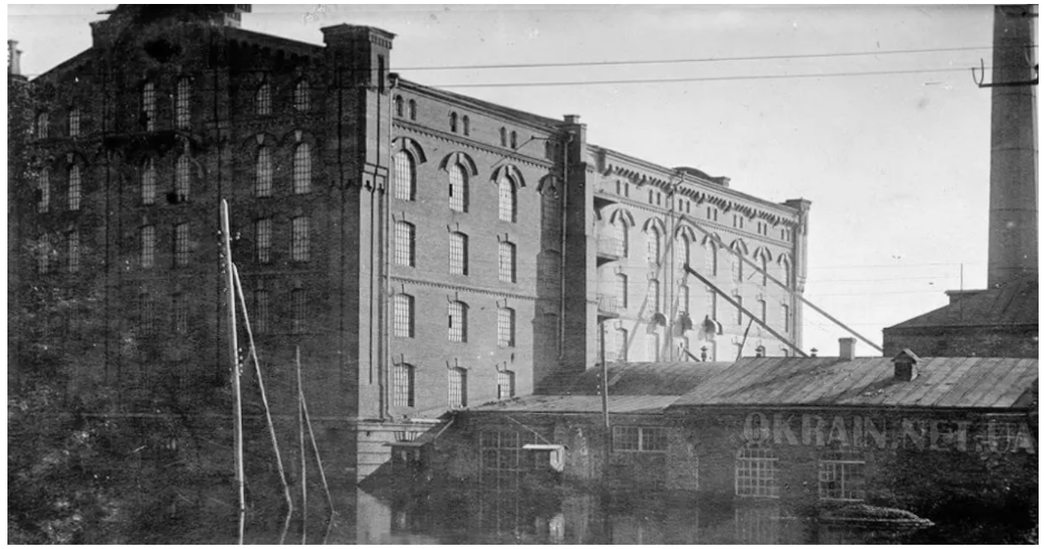


Figure 1. Photo of the flooding in Kremenchuk in 1931.
Source: "ROBMYST", stored in archieves of Kremenchuk Museum of Local Lore, published on okrain.net.ua

Figure 2. Photo of the flooding in Kremenchuk in 1931.
Source: "ROBMYST", stored in archieves of Kremenchuk Museum of Local Lore, published on okrain.net.ua

6.5.3. War threat and flooding

There is another extreme flooding threat that local authorities foresee in the case of the Russian attack on the Kremenchuk Hydro-Power Plant. On September 15th 2022 Telegram channel “Siren Kremenchuk” published the guidelines for the citizens in case of flooding, Figure 4 shows which city districts have to be evacuated for the temporal staying on the first stage.

“The mayor’s office reminds that the enemy’s weapons cannot destroy the entire dam and lead to catastrophic flooding, but damage and flooding are possible, as was the case after the attack on the hydraulic infrastructure in Kryvyi Rih. The so-called “catastrophic flood zone” includes the Khmelnytskyi district of Svitlovodsk and the village of Vlasivka. Kremenchuk is located 11 km from a large hydroelectric power plant, so part of the city is also at risk.” - (Mediadokaz, 2022)

The publication also describes in which settlements people will be replaced for long-term shelter. It shows a certain preparedness of the city authorities, however, the smaller villages might not have the governmental capacity to organise the evacuation to secure the population. Even the flooding area on the Kremenchuk map shows several settlements under the threat. Therefore in adressing of such flooding security issues for rural settlements it is important to raise the capacity and cooperation.

Figure 3. Photo of the flooded central riverfront areas of Kremenchuk in spring 2023.
Source: telegraf.in.ua.

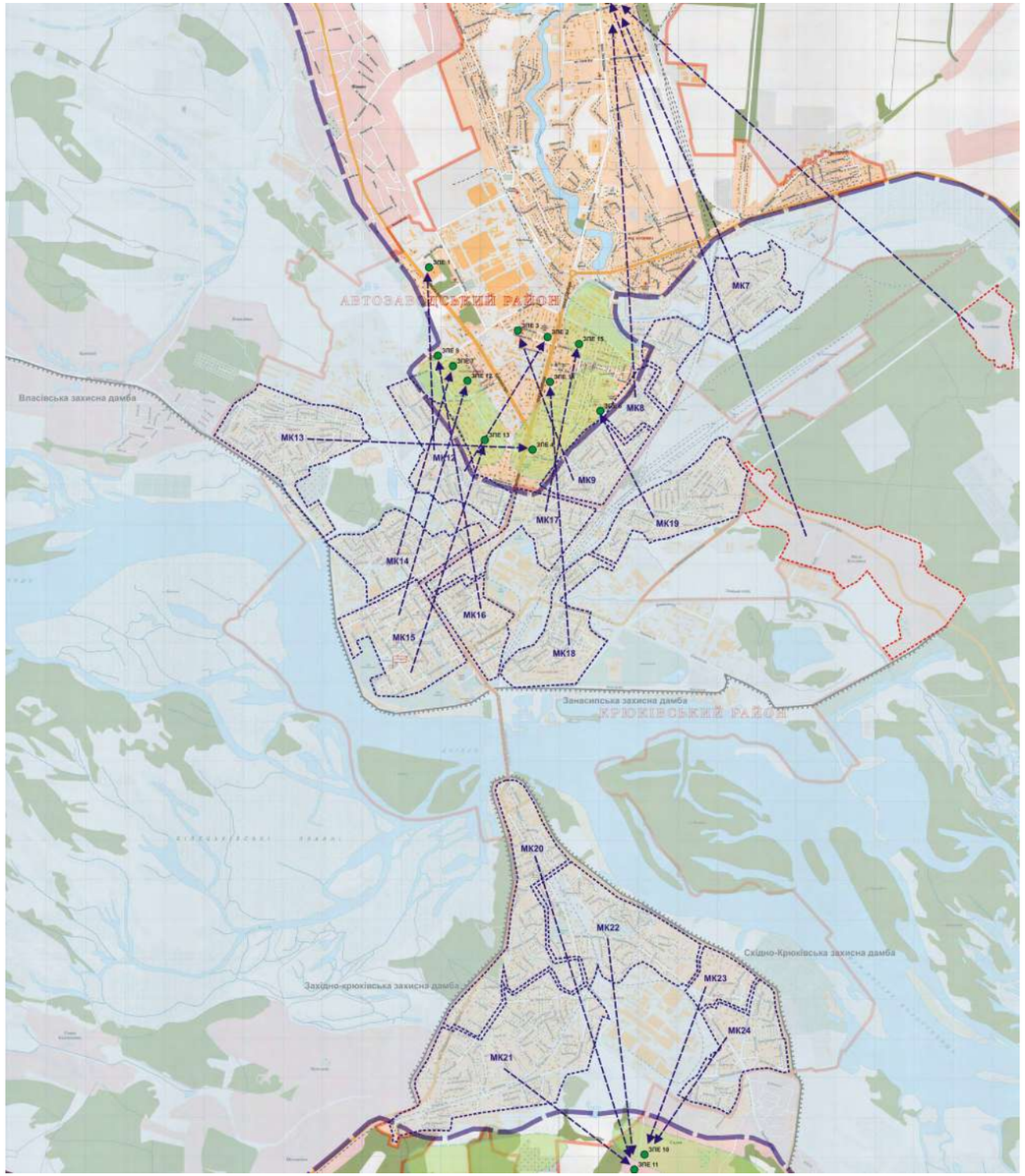


Figure 4. Evacuation assembly points and directions to them
Source: mediadokaz.pl.ua. and Telegram chanel “Siren Kremenchuk”

6.6. Heritage and culture, recreation and tourism

6.6.1. Heritage. Existing quality and ongoing initiatives

As was described in the previous chapters, the historic heritage of the built environment of Kremenchuk is very rich, despite the image of a Soviet industrial monocity. The urban fabric is filled with multiple architectural typologies from different times. Unfortunately, the preservation and regeneration of historic buildings is not prioritized. Many houses from the 19th century are in an emergency state. Some of the buildings from the 20th century are abandoned and also awaiting grading destruction. According to the Historical Architectural Plan, as the city centre was growing from the fortress, the First zone of the historical range (AI.1) is close to the Dnipro River. Therefore, it is crucial to consider the cultural and architectural heritage in the city, while addressing different spatial questions of the River. Even though the work with architectural heritage was not pointed out by local authorities as a strategic direction, we can observe the grassroots initiatives aiming to preserve the historic buildings. The ethnographic community “Okrain Net” raises awareness of the local history of the Kremenchuk and its surroundings through an online portal and regular publications. An activist group “Renovation Map” from Kyiv are currently active in Kremenchuk, sharing knowledge and a respectful approach towards the heritage with the local community. According to Dasha Korba (Renovation Map), there are some underestimated architectural and cultural landmarks, such as the Yurkovskyi synagogue (Figure 2.1) and Kriukiv quartermaster’s (intendant) Warehouse (Figure 1). The case of the Yurovskyi Synagogue, which is planned to be demolished, shows that the architectural heritage in Kremenchuk is not inspected and protected enough. However, there is a certain social demand in the revitalization of abandoned built heritage. The “Dnipro” cinema, situated near the river in Prydniprovskyi Park, holds significance not only as a cultural venue but also as architectural landmark, wich recently obtained an artistic intervention (Figure 2.2.). The aspirations for knowledge sharing about city`s history and landmarks are taken in the form of open events, but also in the form of publications on social media. Another important initiative “Kremenchuk intelligent” promotes the visual identity of the city through the distribution of tourist maps and storytelling on Instagram.

Figure 1. Dasha Korba (Renovation Map) giving the public lecture about the architectural heritage in the Kremenchuk city, 2023. riukiv quartermaster’s (intendant) Warehouse. Source: O`Komova YouTube Channel

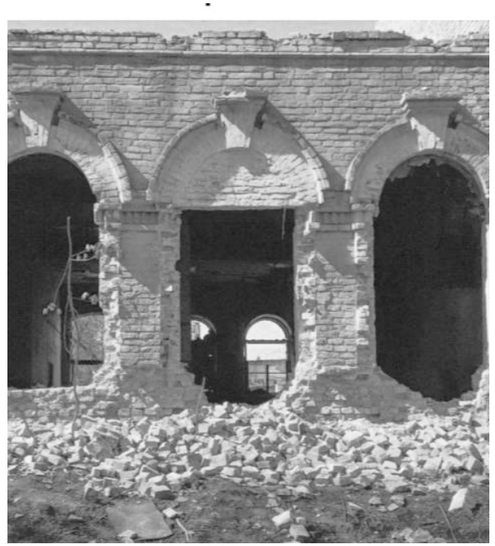


Figure 2.1. Photo of Yurkovsky synagogue
Source: provided by Dasha Korba

Figure 2.2. Photo of the “Dnipro” cinema, 2017
Source: wikipedia.org. Author Oleg Kushch, CC BY-SA 4.0

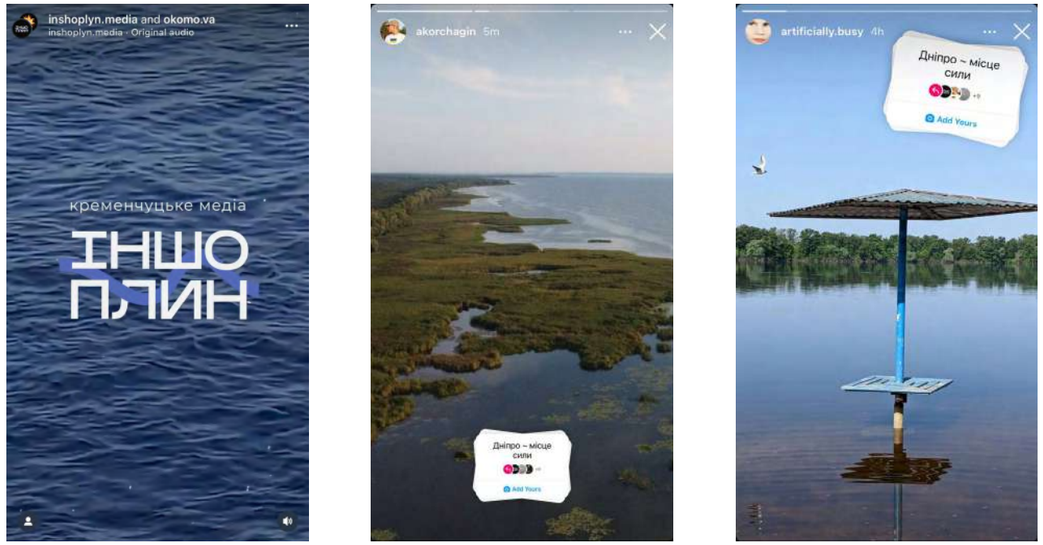


Figure 3.1. Identity of the Kremenchuk based cultural media INSHOLPYN and photos of the Dnipro River within the Add Yours “Dnipro - a place of power” on Instagram
Source: Instagram

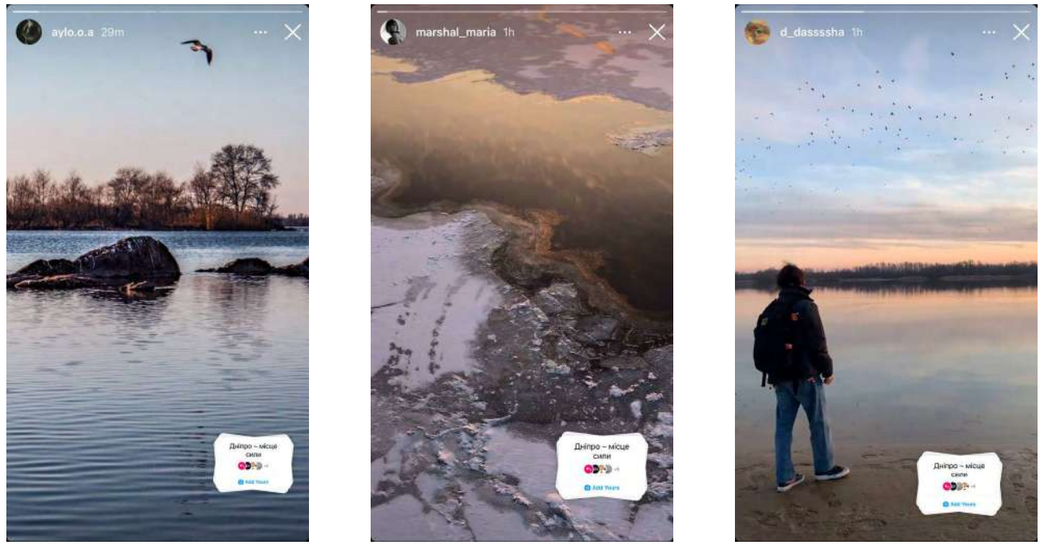


Figure 3.2. Photos of the Dnipro River within the Add Yours “Dnipro - a place of power” on Instagram
Source: Instagram

6.6.2. Cultural Initiatives and the Dnipro River identity today

The Kremenchuk city keeps breaking the stereotypical image of an industrial city by hosting plenty of cultural events, such as Docudays movie festivals, and various music festivals. At the same time, the local cultural community O`komova together with ЕРЦGAMMA studio organizes regular events for the citizens. Interestingly the Dnipro River playing a key role in recreational activities also increases the quality of such events. Nazarii Lisnyi shared the memory about the Dnipro River in Kremenchuk:

“We organized a big festival of Kremenchuk culture in Prydniprovskyi Park, in the city center and at the Pyatak location. It was on July 2. The Dnipro River was literally fifty meters from the festival site, and the festival itself had many zones. In the afternoon, when we had a break in the program, the organizational team and a couple of lecturers decided: “Why don’t we go and swim in the Dnipro River?” So we just went down to the beach and freshened up. It was some kind of absolute summer carefree happiness: there was such a flourishing vibrant Ukrainian culture, lots of young people, we went into the then-clean, cool river - it was a thrill.”

In addition, recently emerged cultural media in Kremenchuk named “INSHOPLYN” was inspired by the identity of the Dnipro River. The media also recently initiated the “Add Yours” photo of the “Dnipro is the place of power” on Instagram (Figure 3.1, 3.2).

Kremenchuk`s flag also references the Dnipro River as part of city`s identity, which is represented by the blue background and the white line symbolizing the Kryukiv bridge. It references to the historically crucial infrastructural role of the city, while the identity of INSHOPLY media emphasizes the natural aspect of the water flow.

6.6.3. Recreational places and touristic attractions

According to the “rayon” scheme of cultural heritage, recreation and tourism - there are plenty of archaeological sites and historic settlements around Kremenchuk city. They are attracting some people from the near settlements and regions, as there are yearly festivals, fairgrounds and tours to the green homestead in the villages: Biletsivka, Checheleve, and Malamivka. Such homesteads propose organic products, ethno-education, eco-education, creative development and recreation. However, these activities are not very attractive for far-distance tourists.

At the same time, the quarry of Horishni Plavni is known as an industrial tourist attraction. Organized groups travel from far away to see the anthropogenic landscape. Often these tours suggest the visit to the regional landscape park Kremenchuk Plavni as the secondary activity. The natural landscape parks are accompanied by camps and holiday centers. One of the most popular recreational activities among the locals is fishing in the Kremenchuk Reservoir and Kamianske Reservoir. The scheme of Kremenchuk`s “rayon” shows 5 thematic touristic routes, that can be taken by car or public transport.

- *route Historical and cultural sites & monuments*
- *route To the places of military glory*
- *route To Kremenchuk Plavni Landscape Regional Park*
- *route To the Folk craftsmen*
- *route of the Farmsteads of Rural Tourism*

Only one of them runs along the river: “To the places of military glory”. The other 4, especially “To Kremenchuk Plavni Landscape Regional Park” have stop points next to the Dnipro, anticipating the recreational activities in the Landscape Park, however, many waterfront areas are not included in the routes, which might be provoked by the low access for cars.

Figure 4. Photo of the square next to the former passangers river port of Kremenchuk (currently Privat Bank)
Source: Hristo Panchev

Figure 5. Photo of the pier next to the the former passangers river port of Kremenchuk
Source: Hristo Panchev

6.6.4. Suggestions: potential for heritage preservation, recreation and tourism

On the city scale, the well-planned connection between the river and the public spaces of the city is immersive. The Dnipro accompanies the cultural activities of the city. As revealed within the waterfront overview (Section 6.3.) there are “chill” recreational areas, sports activities such as sup boarding, yacht clubs, parks, beaches, and a green promenade.

Another interesting area is next to the former river port building, where the concrete square was appropriated by the local fishermen. According to Dasha Korba, this place is the only one that really “belongs” to the fishermen in the city. Additionally, the square opens a marvelous view of the Natural areas therefore it works as an observational point for the citizens. The area also proved its exhibition potential, according to Danylo Orfin, there was an exhibition revealing the city’s history through photography.

Table 4: Suggestions for improvement of cultural and recreational routes

1. Create explorative routes that would consider different types of transition, not only vehicle-based. The areas with low access for cars have a very high potential for cycling routes and hiking close to the river in connection to the existing camps, hostels, homesteads and recreational centers.

2. Rethinking the route “To the places of military glory”. Currently, the route emphasizes the military-related monuments and events along the river. But it can also reveal the change of the river provoked by the war, raising awareness, and educating visitors also about the ecological and cultural aspects related to the Dnipro.

3. Create a tourist route that will reveal different states of the Dnipro River (Figure 7).
    - The route can be taken from both sides of the Kremenhcuk reservoir, to explore the modified conditions of the Kremenchuk “sea”. On the right bank next to Svitlovodsk, there are visible residues of the flooded city of Novoheorhievsk. These places can tell the story of the lost heritage. Crossing the Hydropower plant and other dykes will reveal the anthropogenicaly impacted state of the Dnipro.
    - The intermediate stops reveal the ancient archaeological sites and historic settlements with green craft-related points of interest.
    - The city of Kremenchuk will be a crucial node with the infinite waterfront promenade as the urban heart of this area.
    - In different parts of the route, there are camps, hotels and other tourist infrastructure, but a lot of green and unhabitat areas at the same time.
    - The last part of the route will reveal the natural environment of the Kremenchuk Plavni landscape park, which can be reached on the bike and within hiking routes or by boat from the Kremenchuk boat facilities.

4. Involve different actors in the development of recreational and touristic services. Currently the recreational potential of Kremenchuk city and its surroundings is underused. The unique, almost unchanged state of the Dnipro River should be more known to the Ukrainian public and be attractive to those visiting. The example of the successful development of the tourism business in Kherson Plains proves its feasibility. It needs the involvement of private businesses, municipalities, but also cultural actors that currently work with the identity of the river.

Table 5: Possible cultural and recreational interventions in connection with the Dnipro River

1. Reuse of the open square next to the former river port for the gathering space (Figure 8) - an open fish market/temporal pavilion/amphitheatre/ice skating platform. The waterfront offers many public activities, however, there is no “gathering” space for the big amount of citizens. The integration of the temporal structures for such occasions was made in other Ukrainian cities, with the travelling pavilion of the Sets studio, supported by Creative Europe. Can the local communities such as fishermen’s and cultural grassroots initiatives benefit from the emptiness of urban space and increase the connectivity with the Dnipro River even more? Possibly within these temporal activities in the public space, the reuse of a partially abandoned building also will be conducted in the future.
2. Preservation and reuse of the historic buildings. The Kriukivskyi district, the city center, and the historic and modernist architecture of other districts need to be preserved and restored. Kriukiv quartermaster’s (intendant) Warehouse has a high potential of public connectivity with the river. The former industrial cluster is abandoned and decaying, however, there are green recreational areas with a boundless access to the water right next to it. These areas can benefit from each other by boosting activities and increasing the connectivity and permeability in this part of Kryukiv, just with the slight urban design interventions, preservation of the buildings and its possible reuse for public needs (Figure 8).
3. Collaborations between local initiatives and foreign organisations for cultural and urban development. The local community of the Kremenchuk is getting empowered even in the conditions of the ongoing war, and the cultural initiatives are going on. Such enthusiasm and unity already affect the physical space of the city. The cultural media Inshoplyn also raises the question of sustainable urban mobility which proves the interconnectivity of all the urban and cultural development topics.

Figure 6. Photo of the fisherman on the square next to the former passangers river port of Kremenchuk
Source: Hristo Panchev

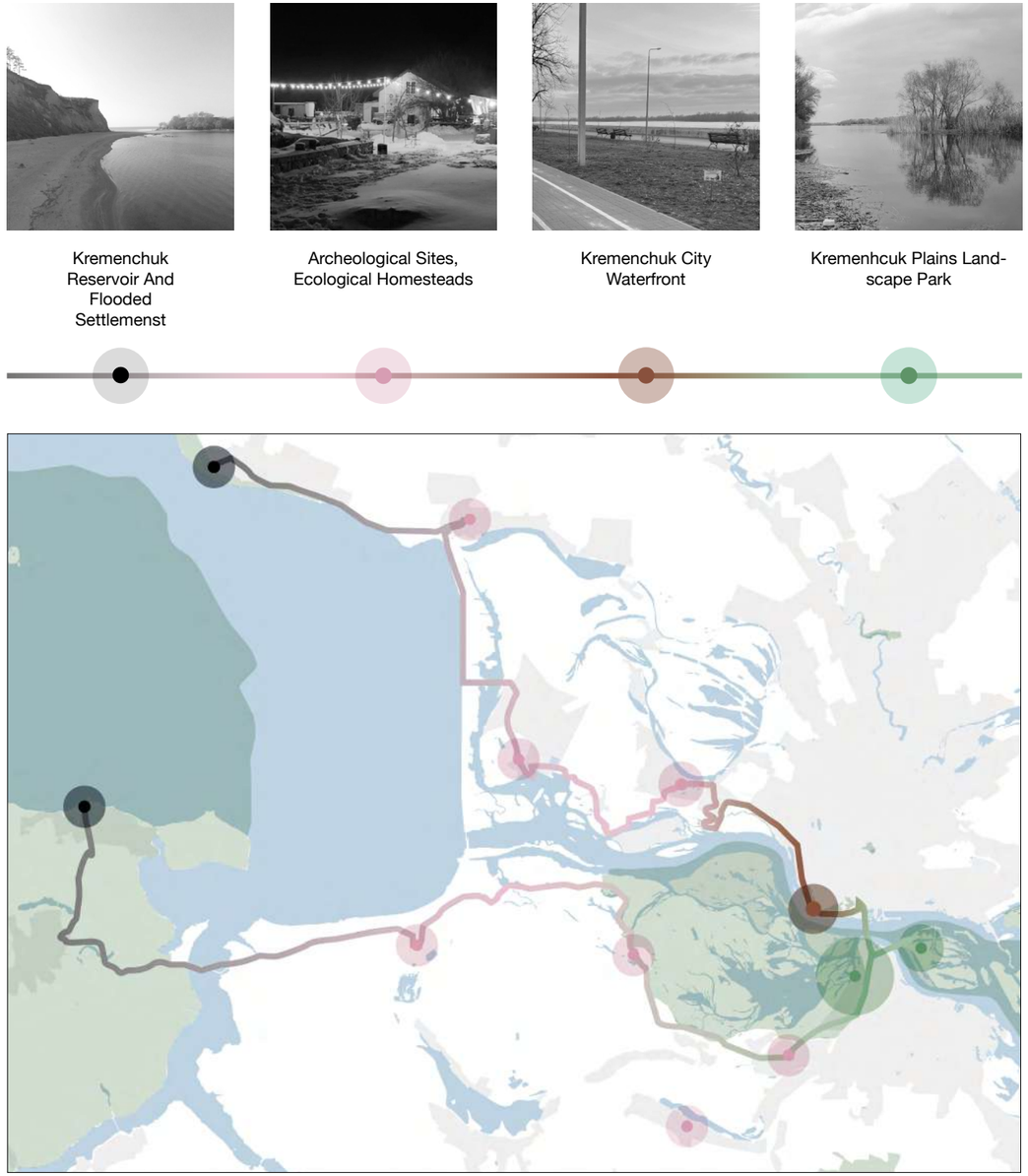


Figure 7. Possible touristic route to explore diferent conditions of the Dnipro River
Elaborated by Ro3kvit and Greenpeace CEE based on diverse data sources

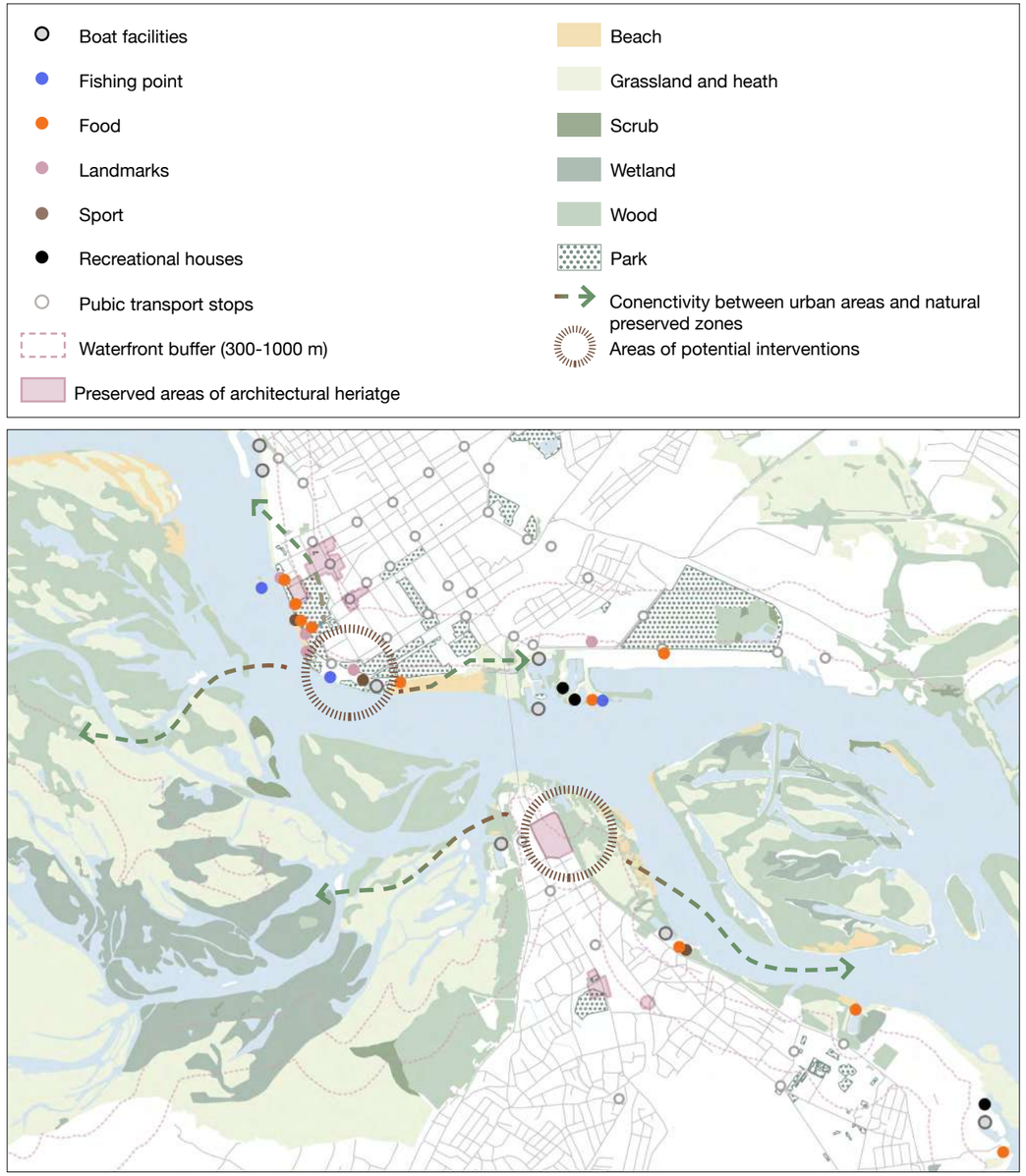


Figure 8. Heritage-related areas and points of interest close to the river (350 meters buffer)
Elaborated by Ro3kvit and Greenpeace CEE

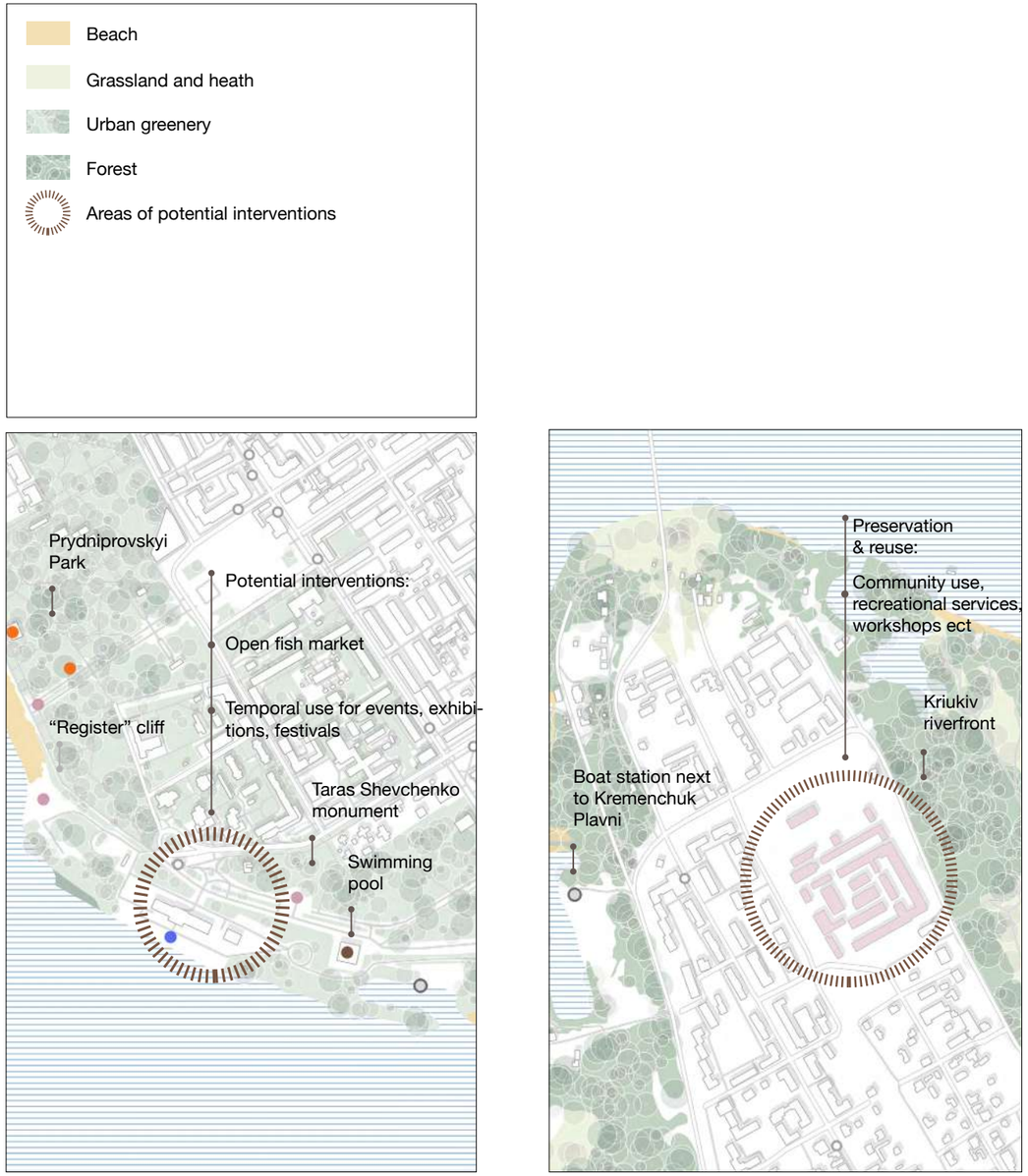


Figure 9. Potential areas of interventions
Elaborated by Ro3kvit and Greenpeace CEE based on diverse open sources

6.7. Economic potential

6.7.1. Existing economic profile: qualities and limitations

Today, the economy of Kremenchuk is in a very difficult position. At the end of the 20th century, there was a boost of industrial development which also stimulated urban expansion. However, according to the analysis from 2015, the share of loss-making enterprises was already 48,3%. Today the situation got worse due to the war and particularly to the damage caused by Russian attacks on the industrial clusters in the city, particularly to the strategic Oil Refinery Factory and Thermal Power Plant (Figure 2). Figure 1 shows that the shear of the workers of the Oil Refinery Factory is significant. Today the workers have lost their jobs with the suspension of the sector, which increased the level of unemployment. The municipality already announced the future reconstruction of the plant, however, the sector is polluting for the environment and not sustainable.

6.7.2. Suggestions for improvement

Therefore there is a question: Are there other ways to improve the economy of the city of Kremenchuk in a more ecologically friendly way? Even today, in the conditions of ongoing war, there is a potential for the planning of economic development.

Sstrategy for Diversification of the economy.
The Kremenchuk`s orientation toward the industrial economy inherited from the soviet times proved its unsustainability in modern times.
It is recommended to diversify the industrial sectors. At the same time, support for the non-industrial sectors is highly needed to prevent the mass migration of young people to bigger cities. The service sector including retail, hospitality and leisure proved its positive impact not only on the economic indicators but also on the quality of life in other Ukrainian cities.

Table 6: Advantages of Economic Diversification

• Stimulation of Job Creation in response to the economic crisis provoked by the war.
• Promotion of Innovation and Entrepreneurship in alignment with the existing municipal program for the business sectors
• Enhancement of Economic Flexibility and Adaptability to avoid dependency on the foreign market
• Improvement of Quality of Life and Social Cohesion within the private and public investment in the urban spaces.

Figure 1. Amount of workers in the biggest industrial enterprises of Krmenechuk in 2015. Elaborated by Elaborated Ro3kvit and Greenpeace CEE based on the data from Development strategy of Kremenchuk (until 2028)

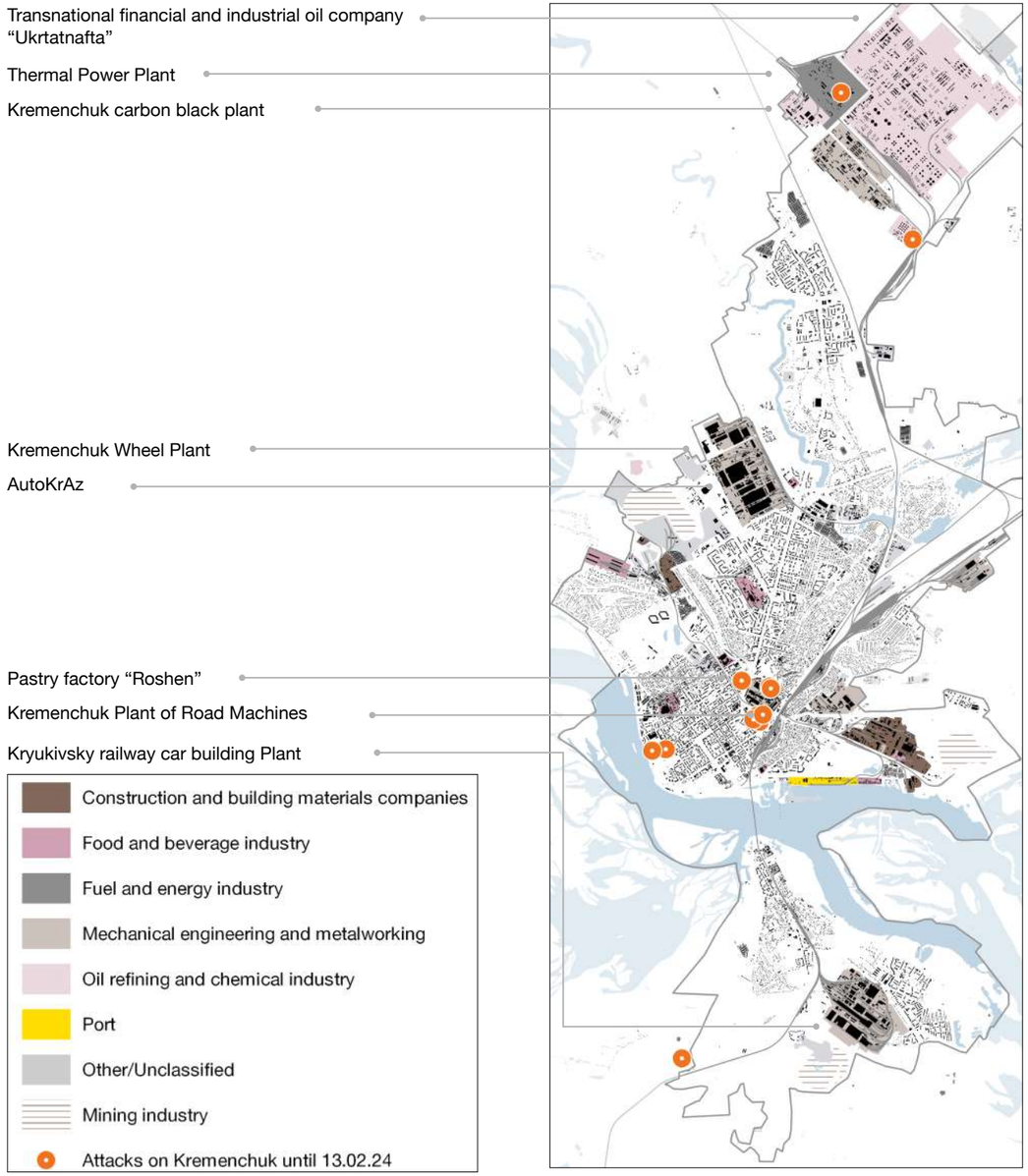


Figure 2. Main industries of Krememnchuk city
Elaborated by Elaborated Ro3kvit and Greenpeace CEE based on the diverse open sources and data provided by eyesonrussia.org.

City Brand & Identity
In different periods of time, the development of the Kremenchuk city was defined by industrial growth. Industrial enterprises invested in cultural and recreational infrastructure which serves the public needs nowadays. Nazarii Lisnyi from INSHOPLYN media mentions that the industrial identity is no longer tangible in the city. The industries stay almost invisible in the urban space, which has a positive impact, leaving more place for the natural identity and human-scale recreational and cultural spaces. Can this identity positively impact the economy?
Natural and recreational components of a Kremenchuk's identity can play a crucial role in shaping its economic destiny. By prioritising these elements, the municipality can foster a vibrant economy that benefits from tourism, housing development, talent attraction, and sustainable practices, ensuring prosperity and high quality of life for all residents (Table 7). Human capital and social innovations also brings benefits for the local economy (Table 8).

Table 7: Dnipro river identity. Benefits for the local economy.

• Brand and Image Building. A strong natural and recreational identity can help Kremenchuk City to differentiate itself and build a unique brand. This identity can be leveraged in informational campaigns to attract tourists, new residents, and investors, further enhancing the economic landscape after the end of the war.
• Tourism and Investment Growth. Such unique areas as Kremenchuk Plavni on the Dnipro River with its natural beauty and recreational opportunities can attract tourists and significantly increase property values, stimulating investment in urban development.
• Attracting Talent and Business Development. Cities that offer a blend of natural and recreational urban identity become magnets for talent and businesses. The availability of outdoor activities and green spaces contributes to a city's reputation as a desirable place to live and work, attracting skilled professionals and encouraging business investment.

Table 8: Human Capital and Social Innovations. Benefits for local economy.

• Human Capital Enhancement is about the development of skills, knowledge, and expertise that individuals possess, which contribute to their productivity and ability to innovate for the local economy.
• Social Innovation for Economic Revitalisation. The approach of starting working with the social issues (not only with economic indicators) and with the local community has great potential. Often leads to the creation of new industries or the revitalisation of existing ones, generating employment and stimulating local economies. Social innovations can improve the quality of life, enhance social cohesion, and attract investment, making the local economy more attractive to both residents and outsiders.

Green energy
The adoption of renewable energy sources can also bring significant benefits to the economy of the Kremenchuk city. Some of them have a direct impact, and some will work in the long-term perspective (Table 9).

Green rehabilitation of industries.
Currently, the concept of Eco-Industrial Parks (EIP) by UNIDO is becoming applicable in different countries. Even within the development of diverse economic sectors, the industries remain as a core for such cities in Kremenchuk. The creation of an industrial park is approved as one of the key prior actions in the Development of Strategy. Therefore it is suggested to consider the framework of the Eco-Industrial Park to address and secure the environmental impact of such development and catalyse the foreign investments for this project. The concept can help to balance the industrial activities and ecological conditions of such important areas of the Kamianske reservoir and its tributaries. The main possibilities for the improvement of the ecological conditions and the Dnipro River in particular within the application of this concept (Table 10).

Table 9: Green Energy use. Benefits for the local economy.

• Energy Independence and Cost Saving. One of the problems mentioned in the Development Strategy of Kremenchuk is lack of the energy self-sufficiency of the city. Indeed the volatility of the fossil fuel market often causes an increase in the supply of heat, electricity and hot water. Implementation of renewable energy technologies can stabilise local energy costs. Lower energy costs translate directly into savings for enterprises and households, increasing the income of the population.
• New Economy Sector Development and Job Creation. Kremenchuk City can consider not only the green renovation projects but also the development of the renewable technologies production cluster. Both can create a wide range of job opportunities in the manufacturing, installation, engineering and maintenance sectors. Considering the declared green direction of Ukraine's reconstruction the local production of technologies and facilities will be very much in value. It will help to lower the unemployment rates that Kremenchuk City faced due to the war.
• Enhanced Brand and Investment Attractiveness. Commitment to renewable energy projects can help Kremenchuk attract additional foreign investment from companies and industries that prioritise sustainability. In addition, the city will be viewed as an innovator and responsible Ukrainian member of the global community, which in the long-term perspective can enhance tourist, scientific and innovation sectors working with sustainable projects after the war.

Table 10: Green rehabilitatiom of industries. Benefits for the Dnipro River.

• Reduced Pollution within the IEP the control measurements. Enhanced Water Management through the adoption of advanced water treatment and recycling technologies.
• Minimised Waste within its convertion into resources.
• Energy Efficiency and Lower Greenhouse Gas Emissions within usage of renewable energy sources.
• Conservation of Natural Habitats through the restoration or preservation of natural areas within the planning of an IEP.

6.8. Water supply: the need for improvement

6.8.1. Existing qualities and limitations

Water supply
In the current context of Ukraine, it is common to utilize a centralized water supply system, which is organized through a pipeline or an open-type water channel with prior extraction of water from a source. Typically, these sources are surface water bodies stored in reservoirs of artificial or anthropogenic origin, with water levels that are regulated. The purification of water for subsequent use in urban water supply systems relies on outdated technologies from the 1960s and 1970s. These technologies are primarily based on group purification methods for various contaminants, along with the capability for bacteriological treatment using chlorine or chlorine-containing compounds, such as sodium hypochlorite and others. Additionally, chlorination of water is frequently practiced during the summer months to ensure bacteriological safety.

This approach in the modern water supply system is considered technically and morally outdated, as the use of chlorine-containing substances negatively affects both the health of the population consuming such water and the ecosystem as a whole. When reconstructing water supply systems, it is essential to consider these factors and implement more sustainable water purification technologies. Additionally, the use of local water sources should be prioritised to ensure relative independence from central water supply systems, which may be disrupted, for example, in the event of the destruction of the Kakhovka Dam, jeopardising the stable water supply to several settlements in the Dnipropetrovsk, Zaporizhzhia, and Kherson regions.

It is also important to highlight the inefficiency of water resource utilization in terms of losses within the water supply system. The total volume of losses can reach 50% or more, including both commercial and technical losses. Typically, the level of technical losses ranges from 25% to 35% (for example, in the case of KP “Vodokanal” in Zaporizhzhia, this amounts to 280.0 m³ per 1000 m³ of extracted water, or 28%), meaning that one-third of the extracted and treated water is lost before reaching the end consumer. The reconstruction of the water supply system must take into account both the technological aspects of water treatment and the technical aspects of reconstructing, modernizing, or building new distribution networks. This would help to avoid or minimize losses, and incorporate decentralized principles to reduce the distance for water delivery. Additionally, it would optimize the use of technological equipment such as pumps, positively affecting the energy balance and consumption patterns of these facilities. Altogether, this could significantly improve the quality of water supply services and the water itself, as well as optimize the tariff policy by reducing costs. To regulate the issue of standardizing expenditures, the requirements are outlined in Article 40 of the Water Code of Ukraine, Article 29 of the Law of Ukraine “On Drinking Water and Drinking Water Supply,” and in the Order of the Ministry of Regional Development, Construction, and Housing and Communal Services of Ukraine No. 179 dated June 25, 2014, which approves the “Procedure for Developing and Approving Technological Standards for Drinking Water Use by Enterprises Providing Centralized Water Supply and/or Sewerage Services.” The target values according to Clause 3, Clause 5 of Chapter II “Procedure for development and approval” are provided in Table 11.

Water disposal
The wastewater management system in Ukrainian settlements is shaped by technology implemented in the 1960s and 1970s. This system relies on sewage pumping stations that transport wastewater either by gravity or under pressure, depending on the city’s terrain, to biological treatment plants. At these plants, the wastewater undergoes mechanical, chemical, and biological treatment, although in some cases, untreated sewage is directly discharged into water bodies.

The management of sewage pumping stations is generally not energy-efficient, presenting opportunities for energy consumption reduction and system optimization.

Additionally, a significant portion of the networks is in a deteriora ted state and requires reconstruction. The biological treatment plants typically involve mechanical processes such as sand removal, followed by grease separation. After this, aeration is used to activate aerobic bacteria, which help in breaking down organic matter. The treated water is then separated from sludge, chlorinated, and discharged into the sea or other water bodies with the necessary permits. The sludge, or slurry, is deposited in storage sites, where it dries under open skies on special fields, releasing pollutants into the atmosphere and emitting a distinctive odor.

Table 11: Key goals from “Procedure for development and approval”.

• The target value for prospective industry-specific individual technological standards for water use, in terms of water losses, to be achieved by 2030, is set at 150 m³ per 1000 m³ of extracted water.
• The target value for prospective industry-specific individual technological standards for water use, in terms of technological water consumption, to be achieved by 2030 for enterprises that use surface water intakes and have contact clarifiers in their treatment scheme is set at 110 m³ per 1000 m³ of extracted water. This goal is to be achieved by improving the technological processes of water extraction, production, and transportation through the implementation of energy-efficient technologies.

6.8.2. Suggestions for improvement

The problem of water cleaning in Kremenchuk was raised several times by municipal authorities.

Table 12 provides the main recommendations for optimizing the operation of the drainage system that will be helpful for Kremecnhuk city and other settlements.

Table 12: Suggestions for the drainage system optimization.

1. Renovation of Water Treatment Networks. The existing water treatment systems are outdated and require replacement or reconstruction. In many cases, replacing the networks is not feasible due to existing infrastructure, making modern renovation technologies the optimal solution.
2. Improving the Energy Efficiency of Pumping Equipment. The current pumping equipment has a low energy efficiency rating. There is significant potential for energy-saving measures, such as installing variable frequency drives and other advanced technologies.
3. Transition to New Biological Treatment Technologies. The use of chlorine for wastewater treatment is no longer effective and necessitates a shift to new biological treatment technologies.
4. Sludge Treatment Using Biogas Reactors. Storing sludge in open fields for natural drying is an unacceptable source of pollution. This sludge can be utilized as raw material for biogas reactors, offering the potential for generating alternative energy.
5. Anaerobic Sludge Treatment in Bioreactors. Anaerobic treatment of wastewater sludge in controlled bioreactors allows for the production of biogas, which can also serve as a source of alternative energy for Ukraine's energy system.
6. Given the high concentration of organic matter in the sludge, alternative treatment methods can significantly enhance energy efficiency and reduce environmental impact. Anaerobic treatment of wastewater sludge in controlled bioreactors can produce up to 6 cubic meters of biogas from 1 cubic meter of sludge. The potential biogas yield from wastewater sludge treated in centralized systems and fully biologically processed at treatment facilities is estimated at 85,000 tons of oil equivalent (2.5 PJ), which is equivalent to 74 million cubic meters of natural gas.

6.9. Energy: efficiency and local production

6.9.1. Kremenchuk Energy Profile

One of the reasons for choosing Kremenchuk as a case study for the Dnipro River Integrated Vision is its energy profile. With its intensive industries on the one hand, and residential, public and commercial buildings with low energy performance on the other, the city is a graphic example of Ukraine's energy inefficiencies, but also of the huge potential for efficiency gains and improvements in terms of energy consumption and the production of local green energy.

Repeated military attacks and damage to the Kremenchuk Combined Heat and Power Plant and the Kremenchuk Hydroelectric Power Plant forced the city to look for temporary solutions. Diesel generators appeared near hospitals and public buildings, new mini gas boilers and old industrial boilers were connected to the grid to provide heat and electricity to homes, wood and coal stoves appeared in many public or social buildings, such as schools and kindergartens. This difficult situation made local authorities very adaptable and open to the potential of green modernisation. In 2023, the Ukrainian environmental organisation Ecoclub organised the installation of 60 kW solar panels on the roof of the "Pravoberezhna" hospital in Kremenchuk. Greenpeace and the German foundation Biohaus are now (May 2024) working to solarise the city's Children's hospital.

As explained in part 4.4. Resilient energy system, the full potential of renewable energy and all other green solutions like battery storage or heat pumps, will only be realised if significant improvements are made to the buildings' efficiency and heating systems.

FIgure 1. The neighbourhood in Kremenchuk and its 35 residential buildings included in the Energy modelling.
Elaborated Ro3kvit and Greenpeace CEE

6.9.2. Kremenchuk Energy Solutions – Energy efficient neighbourhood

To illustrate the real impact of energy efficiency and smart energy solutions in residential and public buildings, several future energy scenarios were tested on a small neighbourhood in Kremenchuk (35 multi-apartment buildings + 1 school and 1 kindergarten) using advanced predictive energy modelling tools. The models simulated possible modernisation strategies using different green technologies available at the time of this report.

The methodology is based on an archetype approach to derive the building data needed to run an Urban Building Energy Model (UBEM) to test the efficacy of energy retrofit policies. This modelling was carried out by the Scottish company Integrated Environmental Solutions (IES, www.iesve.com) for the purposes of the Dnipro River Integrated Vision. Using the Intelligent Communities Lifecycle (ICL) tools, a digital twin of the studied neighbourhood was created to plan, evaluate and manage the community's performance now and in the future. ICL creates dynamic 3D models that reflect real-world performance, delivering resilience, cost savings and resource efficiency for buildings, campuses, communities and cities (Buckley et al., 2021; Dogan & Reinhart, 2017).

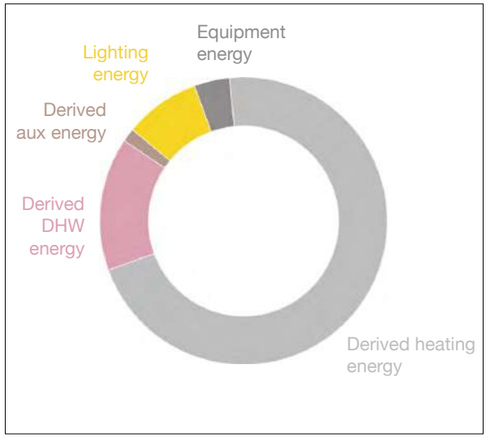
For our study, we collected general building data such as structure, system details and local climate. We used local weather data, and building geometry was obtained from Google Street View, Open Street Map and in-person surveys. Building characteristics and system data were derived from an archive of Soviet-style buildings from 2016. The results showed promising reductions in energy losses and significant improvements in the overall energy performance of the buildings.

The starting point of the modelling is the **Baseline scenario** (Figure 2)**.** It depicts a poorly performing building archetype with the following characteristics:

- Leaky building with 10 air changes per hour (10 ACH), with heat escaping through gaps and cracks in the building envelope;
- Poor thermal performing materials in building envelop allowing heat to transfer via the internal surfaces;
- Gas boilers running the district heating network have a coefficient of performance (CoP) of 0.65, meaning that 35% of the energy used to heat buildings is lost in transmission due to system and fuel source inefficiencies;
- Incandescent light bulbs used to light buildings, which are obsolete and energy intensive to operate.

Gross floor area - **0.201 km2**

Total building energy - **69.2 GWh**



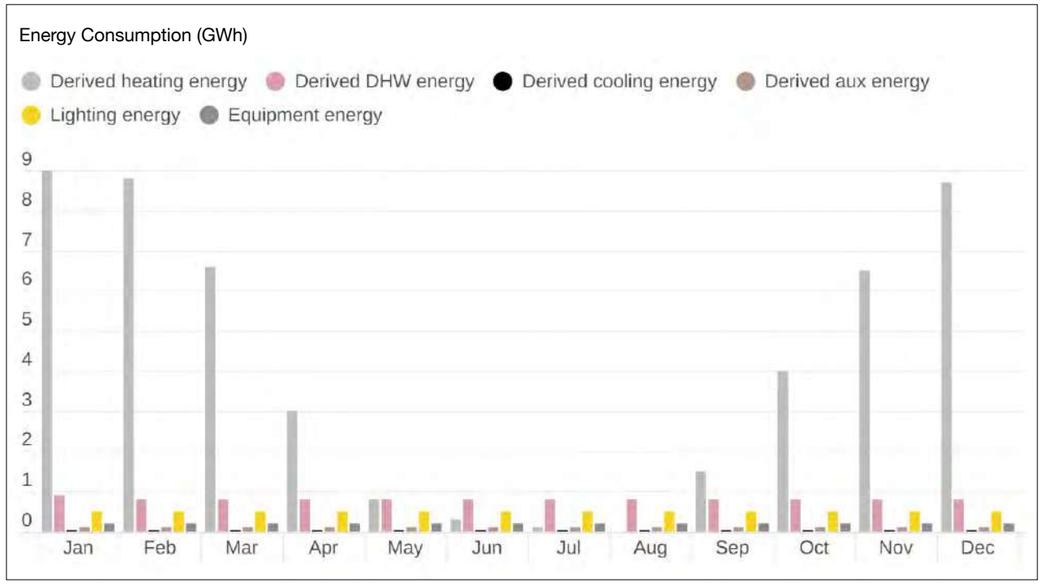


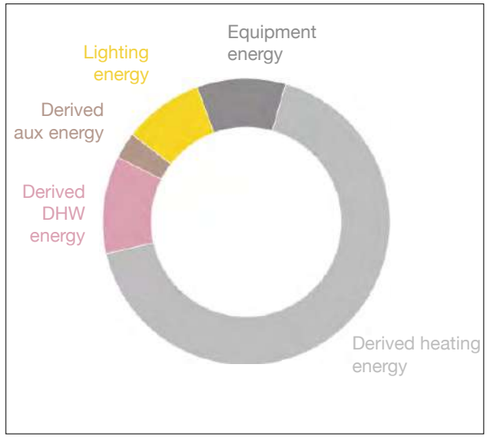
Figure 2. Monthly building energy breakdown in the Baseline scenario
Elaborated Ro3kvit and Greenpeace CEE

The **Standard retrofit scenario**, derived from the analysis of the 35 residential buildings in the neighbourhood, shows that a typical multi-family apartment building, built before 1991, has the potential to reduce its energy consumption by 58% if improvements are made in terms of:

- Improved the air changes per hour (ACH) by improving the airtightness of the building with new envelope retrofit;
- New wall, roof, and floor insulation to reduce heat transfer with external climate;
- New windows properly sealed and insulated to prevent heat transfer through the glass and frame;
- Gas combi boiler updated to reduce energy losses by 30% (0.95 CoP) at district heating plant;
- LED lighting replacing old incandescent bulbs to reduce electricity consumption.

Gross floor area - **0.201 km2**

Total building energy - **28.2 GWh**



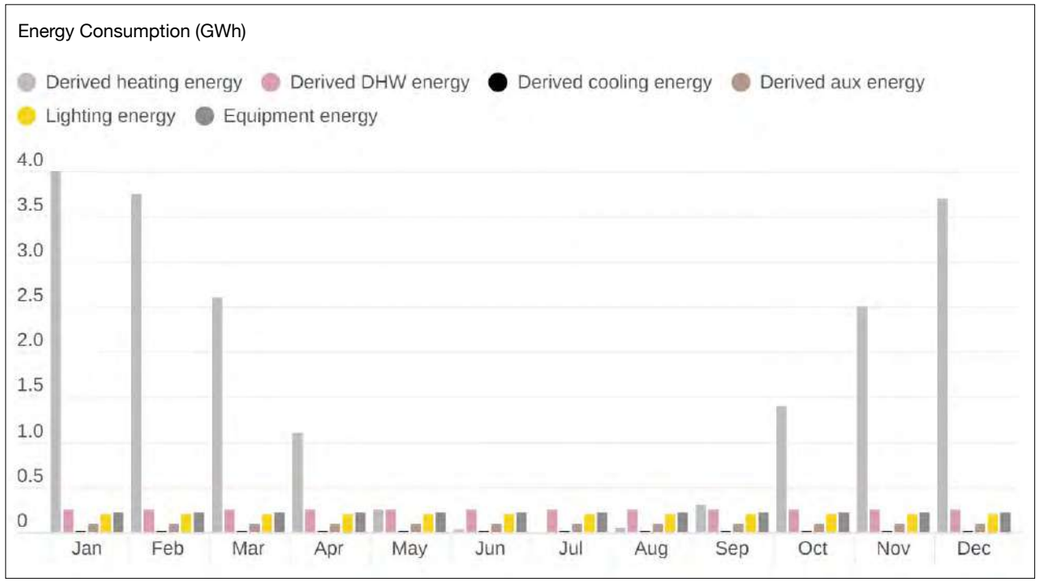
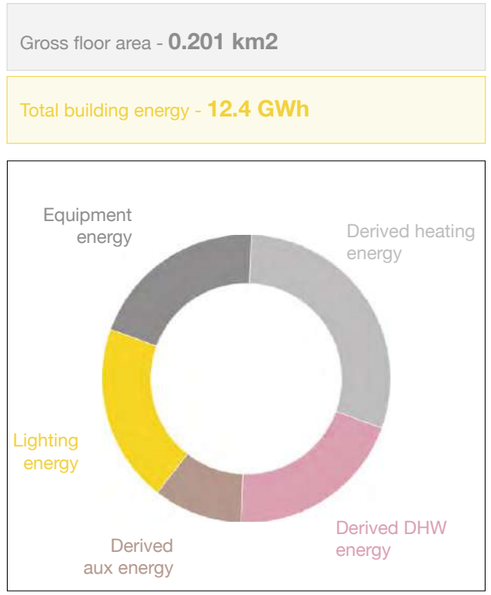


Figure 3. Monthly energy consumption in the Standard scenario
Elaborated Ro3kvit and Greenpeace CEE

The **Advanced retrofit scenario** goes even further by offering a considerable shift in space heating load thanks to improved efficiency of the heating system. That will further reduce the building's overall energy consumption by up to 82%, if improvements are made in terms of:

- ACH, building envelope and lighting remain the same as in the Standard retrofit scenario;
- Gas combi boiler has been replaced with a high efficiency air-to-water heat pump (3.5 CoP) for district heating, powered by electricity.

Additional modelling shows that, under ideal conditions, 1/3 of the energy consumed by all 35 residential buildings in the neighbourhood could be produced locally by solar panels installed on the roofs



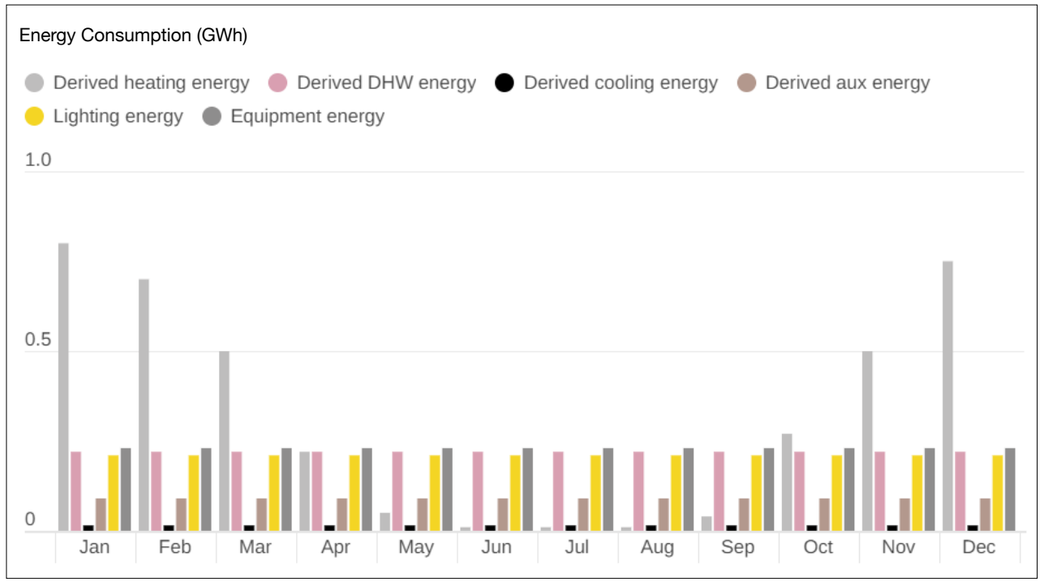


Figure 4. Monthly building energy breakdown in Advanced scenario
Elaborated Ro3kvit and Greenpeace CEE

6.9.3. Energy efficient social infrastructure

To demonstrate the importance of rapid improvement in the energy profile of Ukraine's social infrastructure, our study goes further and provides predictive energy modelling for the following objects of the **social infrastructure of Ukraine:**

- Kindergarten No.33 (Кременчуцький заклад дошкільної освіти (ясла-садок) № 33)
- Secondary school No.25 (Кременчуцький ліцей №25 "Гуманітарний колегіум" № 25)
- Children's hospital (КНМП „Кременчуцька міська дитяча лікарня")

The modelling is based on actual energy consumption data for the 3 buildings provided by the municipality of Kremenchuk. The results show that advanced retrofitting, including an improved heating system, reduces total energy consumption by up to 75% in the kindergarten, 77% in the school and 81% in the hospital.

The Advanced Retrofit scenario, with significant improvements to the hospital buildings, including a high-efficiency heat pump for district heating, the most advanced hospital cooling, heating, ventilation and air conditioning systems (CoP 6), and 75% of the roof covered with PV panels, could achieve potential savings of up to 90% compared to current energy consumption. However, summer cooling loads make it difficult to achieve positive energy hospital buildings with additional renewables.

For the school and kindergarten, the Advanced Retrofit scenario, which includes state-of-the-art heating technologies (high-efficiency heat pump for district heating) together with solar panels covering 75% of the roof surface, makes both buildings Positive Energy Buildings, with an energy surplus of 8% for the kindergarten and 25% for the school. These high values are partly due to the seasonal use of these facilities.

These conditions of the educational institutions make them well suited to play a role in urban energy communities, where citizens, neighbours, households, small businesses and/or organisations come together to produce, consume and manage energy at a local level, while significantly reducing environmental impacts.
In 2022, the municipality of Kremenchuk was responsible for 45 kindergartens, 32 schools and 11 hospitals. Their total electricity consumption in that year was 0.36 GWh, 0.66 GWh and 3.43 GWh respectively. This makes a total of 4.45 GWh. However, these figures only cover electricity consumption, not heat or gas. According to the information provided by the municipality, all of the above social facilities in Kremenchuk consumed exactly 40,934,629 Gcal of thermal energy, mostly supplied by district heating.

If we convert this heat from gigacalories to gigawatt-hours, we find that all these buildings use over 10 times more energy for heating than for electricity. For Kremenchuk alone, the figures show that all kindergartens, schools and hospitals together consumed 40 GWh of heat in 2022. Energy, most of which - as our energy models suggest - can be saved.

The total roof area of all the kindergartens, schools and hospitals in Kremenchuk is approximately 130,000 m2. Needless to say, not all of this area could be used to install solar panels due to shading or construction constraints. However, if only of this area is covered with 450W solar panels (nearly 22,000 solar panels in total), this would give a total capacity of 10 MW or an annual electricity production of 14 GWh. More than three times the electricity currently consumed by all these facilities.

The potential for generating electricity from solar energy on the city's rooftops, however, is much

higher. According to our rough but rather conservative calculations based on the open source GIS database available at www.openstreetmap.org (OSM), the total rooftop area of all public buildings in Kremenchuk is about 275,000 m2, and that of apartment blocks - 725,000 m2. The term public buildings here includes all administrative, cultural and sports buildings, as well as the hospitals, schools and kindergartens discussed above. Residential buildings include only the typical large post-Soviet multi-family apartment blocks (mostly called “panelki” in Ukraine). The different types of buildings were automatically extracted from the OSM database and compared with Kremenchuk’s official master plan (Kremenchuk, 2018).

The roof area of all these building types in Kremenchuk is more than 1 million square metres or 1 km2. If only of this area is covered with 450W solar panels, this would result in a total peak capacity of 75 MW and an annual production of over 106 GWh.

Considering that our energy modelling showed how the social infrastructure buildings in Kremenchuk could be transformed into not only energy neutral but positive energy buildings, and considering the current building profile in Kremenchuk, we can propose recommendations in Table 13.

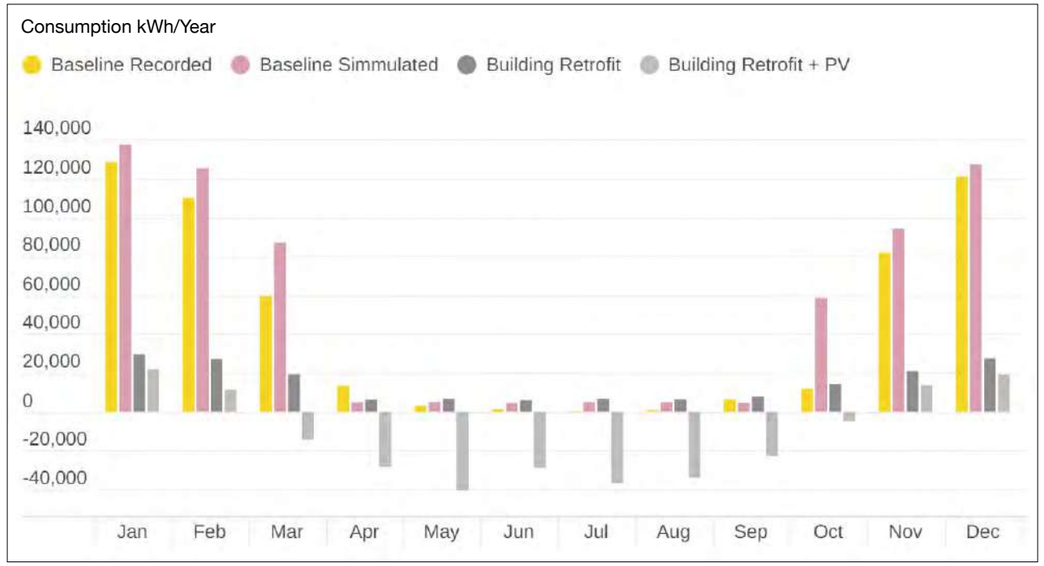


Figure 6. College number 25
Elaborated Ro3kvit and Greenpeace CEE

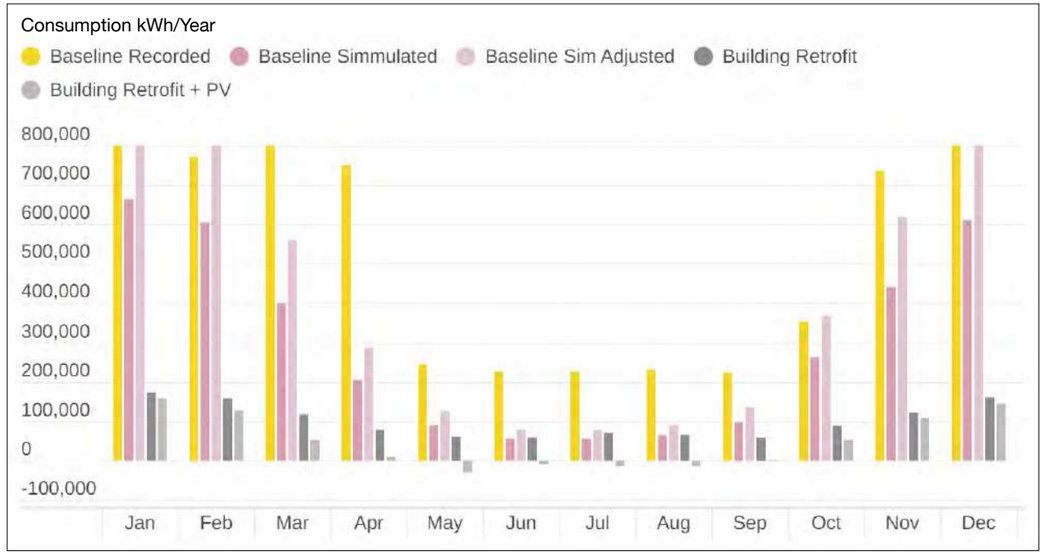


Figure 7. Hospital Sin Scenarious
Elaborated Ro3kvit and Greenpeace CEE

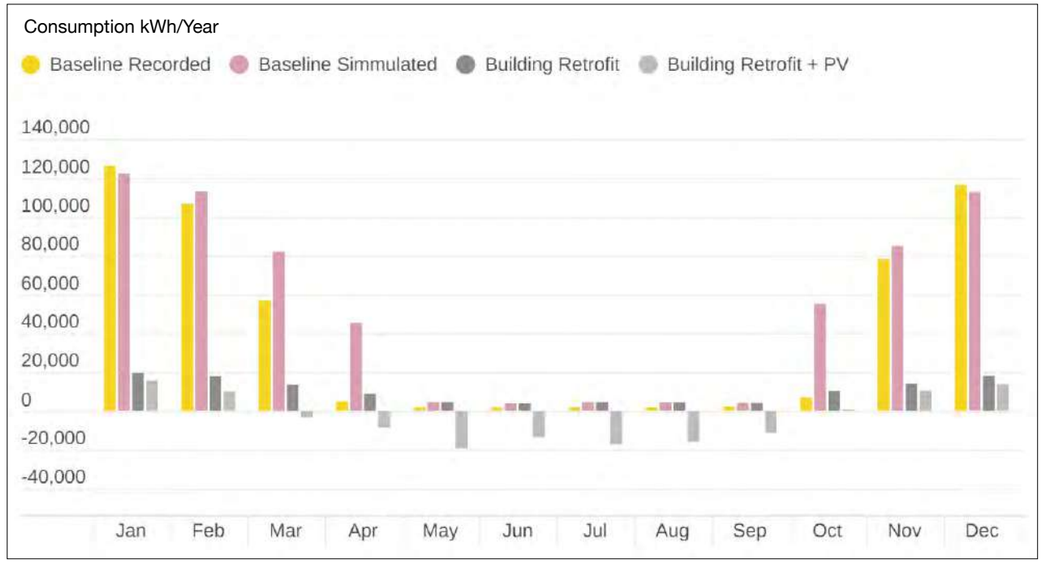


Figure 8. PreSchool Energy Scenarios.
Elaborated Ro3kvit and Greenpeace CEE

Table 13: Recommendations for the energy supply optimization

1.	Improving the energy efficiency of buildings would have a significant impact on the energy profile of the city, its environment and on the country's energy resilience and independence in general
2.	Local and central energy transformation policies should prioritise social infrastructure buildings, with the aim of transforming as many as possible into positive energy buildings
3.	Priority should be given to hospitals as they tend to be more energy intensive, need electricity all year round with no holidays, and are most vulnerable to power outages
4.	Local communities need to be involved and efforts should be made to promote the principles of Energy Communities, as this could be an effective way to finance various green energy projects, including projects to improve the energy profile of public or social buildings in the city
5.	Particular attention should be paid to improving district heating systems by upgrading old heating networks and replacing old sources with new generation heating systems based on high efficiency heat pumps and utilisation of the waste heat from industry, wastewater treatment, or other sources
6.	At both local and central decision-making levels, it is recommended to follow the main principles discussed in part 4.4: diversification of green solutions, decentralisation of energy production and energy democratisation

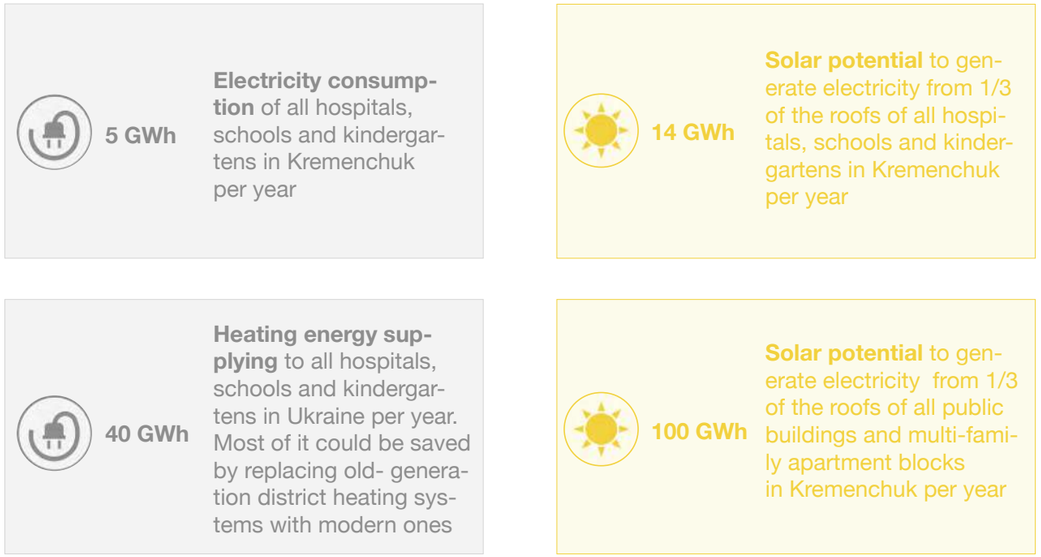


Figure 9. Comparative visualisation of electrical and heat energy consumption, and solar energy production potential. In GWh on an yearly basis. Elaborated Ro3kvit and Greenpeace CEE

6.10. Conclusions on integrated visions

Integrated suggestions

In this chapter, we addressed various thematic issues and potential solutions related to the Dnipro River in Kremenchuk city. Many of these problems are interconnected and can not be considered in isolation. Figure 1. visualises the integration of different thematic fields described within the chapter. The summary is provided in Table 14.

Table 14: Integrated suggestions. Summary.

• As mentioned in the SWOT analysis (6.2.), one of the main strengths of the Kremenchuk is the presence of natural reserves Biletski Plavni and Kremenchuk Plavni. Within the sector of Natural Environment, there is a suggestion to develop research work for the further preservation of biodiversity. On the urban planning level, there is an opportunity to improve the zoning for different types of activities in natural reserves as the current classification does not limit certain activities in the landscape park. This process has the potential not only for biodiversity but also for recreational services improvement and related recreational activities. At the same time, such a process can not be released without the strong collaboration between local authorities, research institutions and involvement of the private sector.
• Local authorities have identified water quality as a critical issue, which is currently maintained by existing supply and treatment facilities. As detailed in section 6.9, implementing ecological treatment systems and updating drainage infrastructures are essential. These solutions can significantly enhance the water quality of the tributaries of the Dnipro River, improve water exchange management in reservoir, and reduce overall anthropogenic impacts. These measures are crucial for mitigating flooding risks.
• Another pressing issue, emphasised in both local authority reports and the Kremenchuk Development Strategy, is the lack of autonomy and efficiency in the energy supply. Given the complexity of the Integrated Urban Planning approach, it is advisable to initiate this application at the neighbourhood level. The energy model for the Molodizhnyi District, as described in section 6.10, exemplifies the principles of decentralised energy supply, energy-efficient renovations, and the capacity for renewable energy applications. These initiatives not only bring benefits to the natural environment but also enhance the quality of life and foster green economic development, which is urgently needed in Kremenchuk in light of the ongoing economic and environmental crises.
• The rising unemployment in industrial enterprises, discussed in section 6.8, is linked to multiple factors, including the ongoing war. Diversification of the economy by stimulating social innovations is one of the key strategies to address this challenge. The Dnipro River remains a vital element of Kremenchuk's identity and holds significant potential for the hospitality sector, closely connected to the cultural perception of the river. Promotion of the river's identity and development of urban services connected to its cultural, touristic, and recreational functions have substantial perspectives. Figure 1 illustrates the interconnections between pedestrian connectivity along the river, the revitalisation of abandoned architectural heritage near the riverfront, and the development of recreational infrastructure for both locals and tourists.

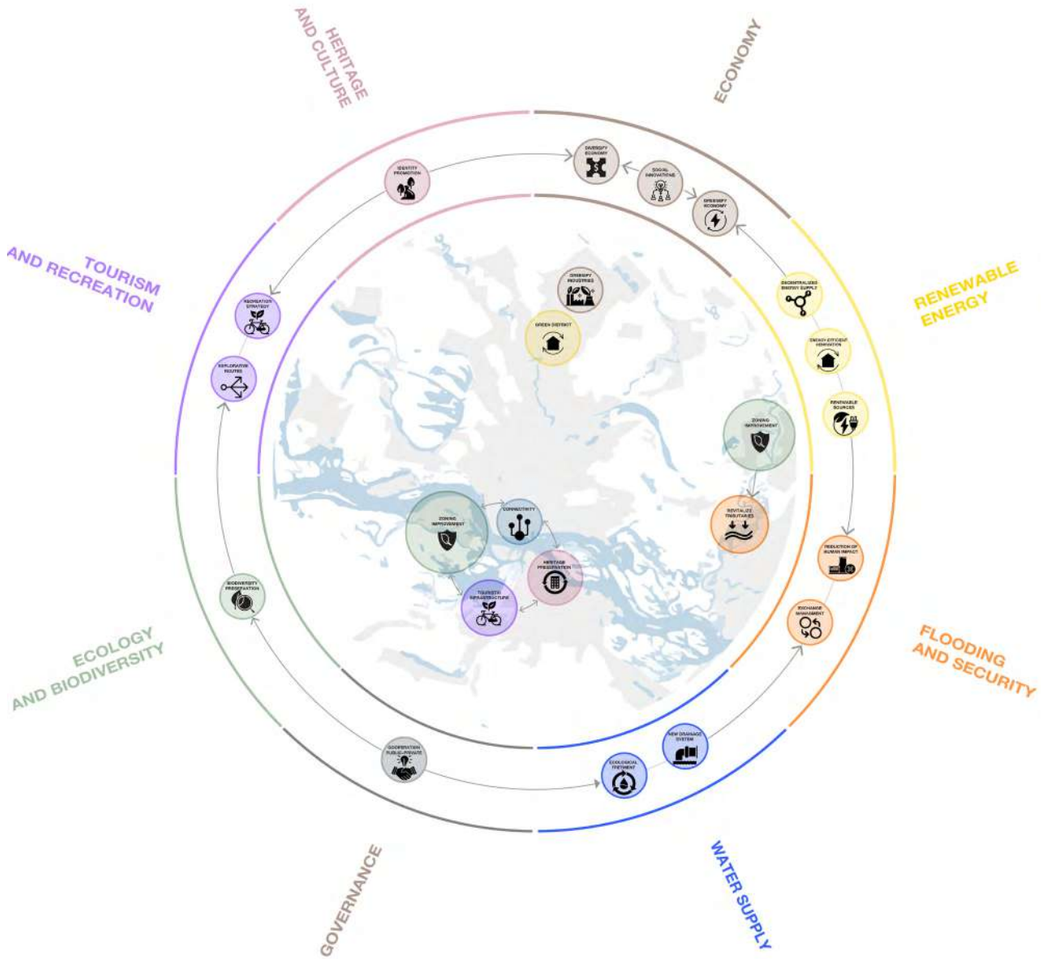
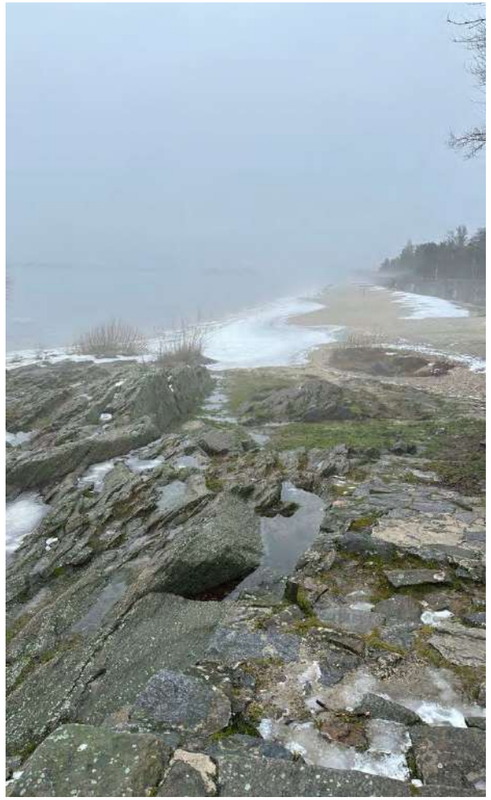
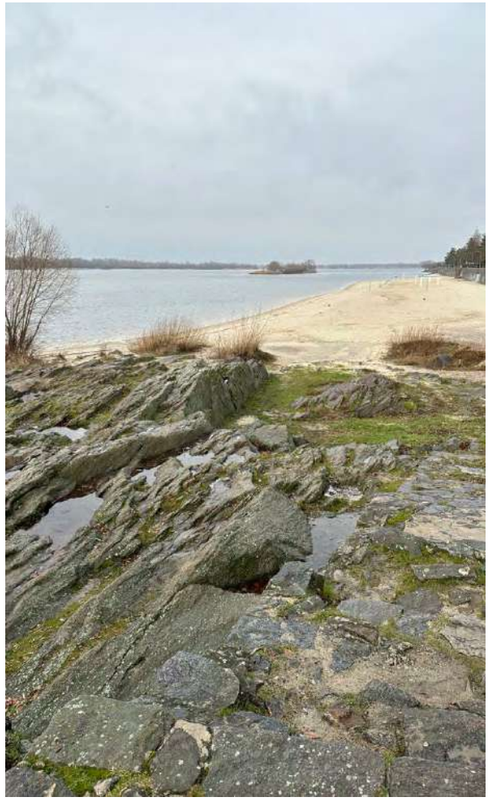


Figure 1. Diagram showing the Integrated vision for the Dnipro River in Kremenchuk
Elaborated Ro3kvit and Greenpeace CEE

Table 15: Advamntages of integrated approach application.

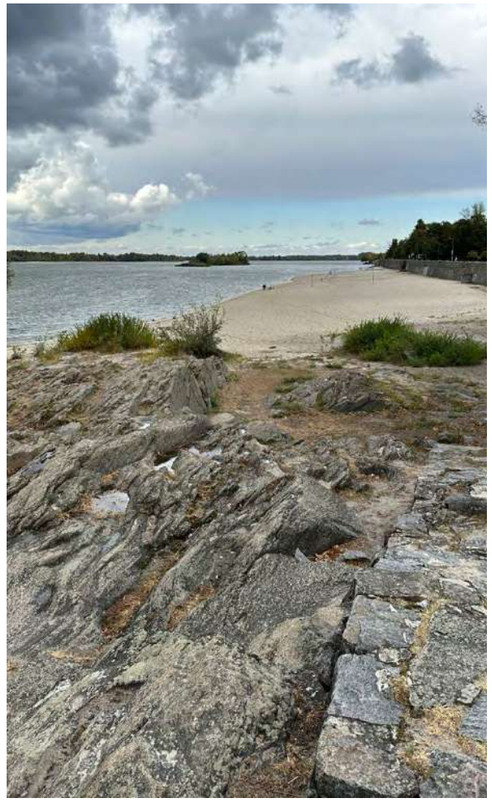
• Achievement of comprehensive solutions to manage resources (including water) in a more resilient and efficient way, as it address climate change, biodiversity loss and pollution (UNEP - UN Environment Programme). Our report emphasises that addressing rivers as a part of urban and rural metabolism will affect many different fields, such as recreation, economy, quality of life, cultural development etc.
• Following the Integrated Urban planning approach in general and for the issues related to the Dnipro River, local authorities can foster collaborations among different stakeholders, including private sectors and local communities. As discussed in Chapter 8, the participation of different experts and authorities is essential for achieving sustainability in the planning process.
• An integrated approach can also empower authorities of Kremenchuk in international collaborations and respond to Sustainability Goals. In addition to that, the correspondence to the principles of the European Green Deal can help to address the reconstruction process of Ukraine in alignment with the national strategy.



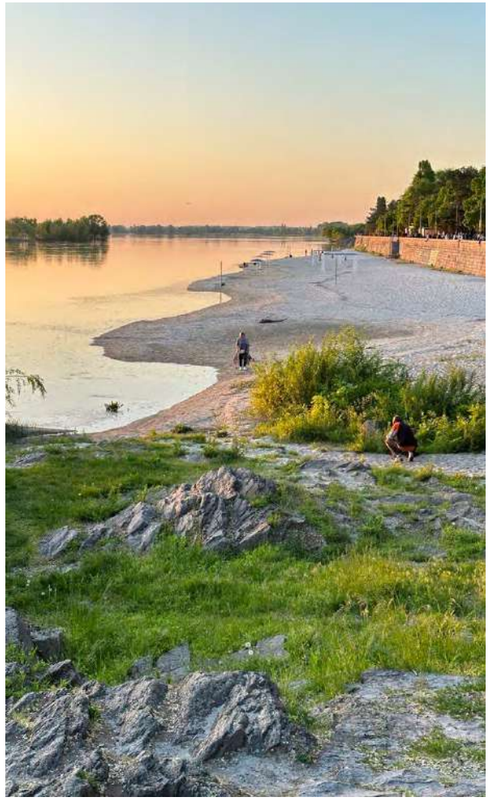


By researching and highlighting strategic areas for improvement, we reveal the importance of an integrated urban planning approach at the local level. This approach is crucial for ensuring that the Dnipro River contributes to the development of sustainable and resilient cities. In both the long- and short-term, the application of integrated planning principles can assist local authorities and professionals with various aspects of planning (Table 15).

This overview highlights the critical interconnections that must be considered when developing specific solutions in any thematic area related to the Dnipro River in an urban environment of Kremenchuk.



Photos of Prydniprovskyi beach and “Register” Cliff in Kremenchuk; Source: Dasha Korba



Part 7

The future of the Kakhovka dam: to rebuild or not to rebuild?

Contents

Summary

In this chapter, we address the pressing debate about the future of the Kakhovka Dam. While many efforts have been made to document the consequences of russia's war crime and ecocide, since russia's terrorist destruction of the dam in 2023, researchers, politicians, the media and experts from different fields have also been actively expressing various opinions regarding "what to do now". Below, we try to summarise the main arguments in favour of rebuilding the Kakhovka dam and reviving the Kakhovka reservoir, as well as those against this.

We compile opinions and arguments expressed in government statements, research and media publications, and conferences. We first present the significant justifications and motivations behind the plans expressed by the government to rebuild the dam. In the second section, we propose alternative judgements. Our last sub-chapter attempts to bring those ideas together and present our views and recommendations about how to move forward. Reflecting on ideas discussed and presented in the previous chapters of this report, we believe that, while neither desired nor planned, the terrorist destruction of the Kakhovka dam can be viewed as an opportunity to rethink how we interact with the river more broadly. With the information available at this moment, Ro3kvit and Greenpeace advise not to rebuild the dam in its pre-war form but to start rethinking the relevance of the dam in the current conditions. Ultimately, there is a need to find and design new balanced solutions for a healthy, future-proof river and economy based on deeper on-site research, debates and discussions.

7.1. Rebuilding: the arguments for

Introduction

A few weeks after the Kakhovka dam was destroyed, the Ukrainian government declared its intention to rebuild the dam. On July 18th, 2023, the Cabinet of Ministers of Ukraine, namely, Prime Minister Denys Shmyhal and the Ministry of Economy, approved the realisation of the experimental project for the reconstruction of the hydroelectric structure of the Kakhovka HES (Government Portal, 2023).

The project was divided into two stages. The first stage is said to involve the design of temporary dams and the reconstruction of retaining structures for the lower and upper pools for the hydroelectric station, aimed, among others, at maintaining necessary conditions for the operation of the DniproHES upstream. The second stage involves the inspection, dismantling of the destroyed structures and the development of a project for the construction of the new Kakhovka HES, and is conditional to the de-occupation of the Kakhovka HES from russian forces (Forbes, 2023).

The arguments for the reconstruction of the dam are not senseless. After all, they are grounded in the established socioeconomic balance that has formed in the regions around the Kakhovka reservoir for decades, and the existence of the Kakhovka HES seems vital. An analysis by Maksym Fedoseyenko from the Kyiv School of Economics, dated June 27th 2023, presents four main arguments in favour of the reconstruction, which is also predominantly reflected in official statements by the state-owned Ukrhydroenergo — the main stakeholder in the operation of the Dnipro River Hydropower plans (Forbes, 2023).

7.1.1. The benefits from rebuilding the Kakhovka dam

1. Navigation
Firstly, as discussed in the first parts of this report, the Kakhovka Hydroelectric Station facilitated logistics along the Dnipro River, and its locks were an extremely important component of the cascade of hydraulic structures on the river, which made navigation possible not only in the area where the station is located but also along the entire length of the Dnipro River (CFTS, 2023]

2. Water for Agriculture
the water from the Kakhovka reservoir played a crucial role in agriculture in the southern regions of Ukraine. According to reports from the Ministry of Agrarian Policy, 94% of irrigation systems in the Kherson region relied on the Kakhovka Reservoir, while in the Zaporizhzhia and Dnipropetrovsk regions, the figures were 74% and 30%, respectively (Minagro, 2023). The reservoir provided water for irrigation systems and livestock across a total area of 584,000 hectares. As a result, indirect income losses for crop production are projected to increase by $182 million annually, according to KSE estimations (KSE, 2023).

3. Energy security
another major consideration involves the importance of the Kakhovka Reservoir for the operation and cooling of the Zaporizhzhia NPP, currently occupied by Russia. At present, the minimum water level in the pond is maintained through an alternative channel from the Zaporizhzhia Thermal Power Station, which is also temporarily occupied by Russian forces. However, this is only sufficient to support the shutdown reactors.

4. Energy capacity
Lastly, the Kakhovka HES itself is, of course, considered an important source of electricity production, mainly for the regulation of consumption levels. The hydroelectric station is also a source of green energy, which is a development priority in the energy sector of EU countries. The main advantage of hydroelectric energy is based on the additional manoeuvring capacities, which are required to balance the energy system and which neither nuclear, green wind nor solar energy can provide.

The estimated cost of the reconstruction constitutes over 1 billion USD. According to preliminary calculations provided by the head of Ukrhydroenergo Ihor Syrota in June 2024, the Kakhovka HES can be rebuilt within 6-7 years. Previously, a minimum period of 5 years had been reported. Importantly, however, Syrota stresses that this will only be possible “after the territory is de-occupied from russian armed forces”, continuing that only “then we will be able to drain the site where the explosion occurred, conduct inspections, and dismantle the destroyed structures and facilities of the Kakhovka hydroelectric complex” (E-Pravda 2024).

7.2. The arguments against rebuilding

Introduction

While the plans to rebuild the Kakhovka dam and HES have been supported by the government, they have also generated a lot of debate among experts in various fields, who have significantly questioned and criticised the intention to reconstruct the dam, commenting both on the feasibility of the construction, but more importantly, on the consequences it may generate. Based on the objectives outlined in the government plan (river navigation, energy production and the water supply for agriculture and energy security), but also with consideration of wider aspects discussed in previous parts of this report (ecology and biodiversity, culture and heritage, safety and security), we present below arguments against the reconstruction of the Kakhovka HES, and in favour of preserving the environment in the current state.

Figure 1. An image of the Zaporizhzhia Nuclear Power Plant (currently occupied by the russian military), viewed from across the right bank under Ukrainian control. The photo is extracted from a video on Nikopol. Author/Source: Хащі / Youtube, 2024.

7.2.1. Feasibility, safety and security

First and foremost, the feasibility of the project is put under question. On the one hand, the reconstruction was said to require significant financial resources of over 1 billion USD. It is arguable whether this is the most efficient use of funds to respond to the various challenges outlined before. More importantly, however, the plans to rebuild the Kakhovka dam are contingent on the future path of the war, which makes any future plans for the reconstruction both risky and complicated.

At the time when this report is being written (May 2024), the left bank of the Dnipro River in the regions of Kherson and Zaporizhzhia are still controlled by the russian armed forces, and the territories in proximity to or directly in the Dnipro River remain at high risk of being targeted by russian military attacks. Daily threats remain, making any construction work, if not impossible, then highly dangerous. The security of highly immobile and large-scale infrastructure required in the construction of a hydroelectric station of the scale of the Kakhovka dam cannot be guaranteed.

Moreover, considering the situation where the left bank is successfully de-occupied from russian armed forces, several issues persist. How far should the frontline be to consider the construction safe? As the examples of the russian attacks on the DniproHES show, no air defence system can provide 100% safety, and even in the case of the complete de-occupation of the territory of Ukraine, including the eastern regions and Crimea, russian missiles and drones remain a tangible threat.

That said, another issue related to the safety and security of any works on the Dnipro River involves the challenge of de-mining. With the frontline lying along the Dnipro River, the presence of hazardous and explosive military objects is an issue that will require particular attention. In shallow or deep water, in mud, swamps, and streams. The de-mining of a river bank or reservoir takes time, is expensive and is more than dangerous. Leaving the mines where they are might lead to unexpected explosions or leakage, with all environmental and health risks as a result.

7.2.2. Water for households and agriculture

A large humanitarian and economic risk is foreseen when the water for households and agriculture cannot be provided. When it comes to the supply of water for the population, which was previously sourced from the Kakhovka Reservoir to cities and municipalities along the river, new alternatives and technologies are inciting to reevaluate the need for the construction of the Reservoir. At this moment, the alternatives for the drinking water for the territory of Dnipropetrovsk, Zaporizhzhia, and Kherson regions, previously provided by the Kakhovka Reservoir, are almost realised.

Communications – new pipelines – are laid to alternative water sources, and new wells are being drilled for groundwater usage. The construction of the a new water pipeline from the River Inhulets to the city of Kryvyi Rih by "Avtomagistral-Pivden," is said to be the largest construction project related to water-provision realised in Ukraine during the period of independence. The new water pipeline is designed to supply 400,000 cubic meters of water daily. The total length of the pipelines is 118 km (Censor.NET, 2024).

At this moment, good alternatives for drinking water are almost realised.

So, while the question remains open for the territories on the occupied left-bank of the Dnipro River where Ukraine is unable to assess damages or conduct works, current works have shown that the necessity of a Reservoir for water supply should be reevaluated.

At the same time, the supply of water for agriculture has also been described as a major rationale for the reconstruction of the dam. While the Kakhovka reservoir was central to water provision through irrigation canals, as described in *4.5. Modernised agriculture*, alternative technologies must also be considered, allowing for a more efficient use of water. New water pipelines should be considered as an option, along with modernised water usage involving dripping water technologies. These arguments, again, put under question the necessity or reasonability behind the reconstruction of the Kakhovka Reservoir in the same form as it used to exist.

7.2.3. Energy supply

When it comes to energy production and energy supply, there is an urgent need to think of a radical re-imagination of Ukraine's energy system. The destructions caused by Russia to Ukraine's energy sector do not allow to frame discussions in the same way they used to be. The additional manoeuvring capacities of hydroelectric power are not put under question, but the question arises whether the construction of the new Kakhovka HES provides more benefits than costs, considering all other aspects discussed above and below. Will not equivalent investments in more resilient alternative energy production sources and the increase in energy efficiency be more conductive? It is cheaper, safer and faster to build fields for solar and wind energy. By the time the dam could be restored after peace, the alternative sources had already been there for some time, also being more powerful and more capital-efficient. At the same time, it is important to realise that with the war ongoing, Ukraine is facing significant demographic changes and must consider various scenarios for the future.

7.2.4. The natural environment

From an ecological point of view, many Ukrainian researchers and conservation groups have already expressed their support for the preservation of the territories liberated from the water after the destruction of the dam. The natural environment around the reservoir has been changing rapidly, and it is hard to assess its value for the environment.

On the one side, it is true that predictions for the future cannot be certain. The initial risks of the formation of a desert were quickly refuted by the quick growth of plants on the bottom of the former reservoir. Similarly, concerns that invasive vegetation might constitute a threat to native ecosystems have been refuted, with recent estimates presented at the scientific Conference “The Kakhovka Reservoir Disaster” (June 6th, 2024) highlighting a rate of 25% of alien species compared to 75% native. Nevertheless, some are still concerned that the ecosystems of the Great Meadow will not survive because of rising temperatures (a consequence of climate change) and increasing dust storms (Open Forest).

The factor of yearly Vodopilia (”high water” or “flooding”) can be helpful for vegetation to resist such threats. It happened in the spring of 2024 for the first time in the last 70 years and significantly humidified the territory of Velykyi Luh. Ecologists admit that the development of biodiversity will very much depend on next year’s Vodopilia (UNCG, 2023). Maksym Soroka, a scientist from Zaporizhzhia highlights that the former Velykyi Luh will never be recovered in the conditions it was before the creation of reservoir. Therefore he calls for avoiding rash conclusions and consciously weighing the dynamics (Media literacy in Ukraine’s regions, 2023).

But, considering that the reconstruction of the dam is unlikely to be delivered in the next years due to the ongoing military activities, a new natural ecosystem has the chance of being formed, potentially revealing further benefits of the new geography. After all, a major consideration that should be taken into account here is that, in the first place, the construction of the Kakhovka dam in 1956 destroyed the natural ecosystems and biodiversity.

Many have seen the current events as an opportunity to restore the lost ecosystems. From an ecological point of view, the recovery of Velykyi Luh (”Great Meadow”) and the many other territories that were submerged underwater for decades is seen as favourable. Many ecologists from the Ukrainian Natural Conservation Group (UNCG) stand against the project for the Hydro Power Plant and reservoir, claiming that it might destroy the ecosystem that has begun to recover. Some have said that a new Kakhovka reservoir will become another ecocide, destroying plants and animals. According to the field research, there is already some vegetation growth, particularly poplars and willows, which are estimated to form forests in the next 5-10 years.

Figure 2 and 3. Photographs of the Dnipro River around Nikopol, in the areas previously covered by the Kakhovka Reservoir. The photo is extracted from a video about Nikopol. Author/Source: Хащі / Youtube, 2024.

7.2.5. Navigation

When it comes to water transport, it is conventionally considered that the Reservoir is inevitable for river navigation. Nevertheless, that is not the opinion of some of the major players involved in river navigation. In an interview conducted in the course of our own research, deputy CFO at Ukrrichflot Yurii Tereshchenko expressed the view that for the restoration of navigation along the Dnipro River, it is not necessarily required to rebuild the Kakhovka Hydroelectric Power Plant in the way it used to be. A possible alternative that would be sufficient to connect the upper Dnipro with Kherson and the Black Sea could be the construction of a navigable canal along with mechanisms that can raise or lower vessels. Similar arguments have also been expressed by the former Minister of Infrastructure of Ukraine, Volodymyr Omelyan (Latifundist, 2023)

7.2.6. Culture

Lastly, as discussed in our previous chapters, the cultural significance of the Velikiy Luh and of other places along the original Dnipro riverbed should not be taken out of the equation. A rich heritage became visible after the dam has been exploded. Boats, houses, villages, and personal items. From different eras, even back to the Cossack times. Of course, all Ukrainians understand that these items are of high value for the Ukrainian culture and identity. But what if we think of it the other way around? What if, for some water-related reason, the reservoir should and would be refilled again? What would that mean for the history of Ukraine?

Yevhen Synytsia (Chairman of the Board of the Ukrainian Association of Archaeologists) emphasises that there are not only the archaeological sites of the Cossack Sich but dozens, if not hundreds, of other eras. Considering the plan for the new reservoir, there will be very little amount of time to conduct the expeditions. In addition, illegal excavations have already taken place. At the same time, the capacity for conducting deep studies is not enough. According to Synitsia, to be ready to start after the end of the war, the planning and training of experts should be taken as soon as possible, as there is a real threat of losing an important historical layer again.

Interviewing
Oleksandr Kolosiuk

53 years old

As a Kyiv resident, I now live in the suburban town of Rzhyshchiv, situated on the banks of the Dnipro River. My wife, Kateryna, and I have been running an educational and recreational tourism project for about a decade. We involve our friends and anyone interested in recreation, sports, and creating new values within our local community. Nature conservation plays a crucial role in our project.

Previously, I worked as a project manager in the car industry in Kyiv. However, after discovering new priorities in life, I decided to change my career path. Now, we strive to interact with the local community, introducing new ideas and projects. Our main goal is to create new values. People from various fields should share a common vision of what we need to improve our country and our future, using their knowledge and expertise to make a difference. My wife and I have chosen our field based on our experience and motivation.

I have spent my entire life in the Dnipro River basin, surrounded by its tributaries, lakes, and streams. My childhood was spent on the banks of the Dnipro itself or its nearby bodies of water. The most vivid and impactful memories often stem from childhood. One of my strongest recollections is a trip along the Dnipro from Kyiv to Kaniv, to the grave of Taras Shevchenko. The scenery along the Dnipro's banks is just as Shevchenko described it. This memory significantly influenced our decision to move from the city to these picturesque suburbs. I also remember taking a boat trip with my parents up the Dnipro River from the city to the newly-constructed Kyiv Reservoir. I can still recall the range of colors, sensations, and smells. Back then, the Dnipro definitely had the scent of a river. However, now the river barely flows. At that time, there was still a current in the Kyiv water area, with its own ecology, flora, and fauna.

Forty to fifty years after the construction of the dams, it is particularly noticeable how much the river has silted up. The current is gone, and it is gradually turning into a swamp.

We no longer live on the banks of a river, but on the banks of a reservoir that is becoming a swamp. The Dnipro is not only a natural element but also a cultural one for our entire nation. Looking back historically, the most recent changes to the Dnipro—the construction of the dams—did not happen by the will of the Ukrainian people. The strategies of electrification, transportation route development, and agricultural development were all imposed on us by Moscow. The project of building dams on the Dnipro primarily served the military purposes of a totalitarian state.

As our country is being reshaped, the river also demands a new approach. We need to formulate a fresh strategy for the development of the country and the Dnipro as the main element that unites the two banks and shapes our culture in a certain way. Our country is incomplete without the Dnipro, without the river.

We organize tourist and excursion routes near the Dnipro River, but if the river were truly a river and not what it is now, it would offer far more opportunities, even in this aspect. Although beautiful views can sometimes be seen, and nature itself provides certain services, these services need to be evaluated, inventoried, and their profitability calculated.

We must determine whether it is more beneficial to reduce the number of reservoirs and free up vast spaces for agriculture or to raise the dam levels, perform aeration, and reduce evaporation. However, it is clear that we cannot leave things as they are, because the river has ceased to be a river altogether. If no action is taken, the river will disappear and become a swamp.

Strategically and philosophically, the situation is straightforward. There was a river that shaped our culture, inspired many people, and provided for their needs. However, at the beginning of the last century, Ukraine was invaded by Muscovite occupiers who did to the river what they saw fit for themselves, not for Ukraine. If we want to become a truly successful, independent country, we need to change everything to the way we see fit, because that is how it should be. The very dialectic of this current historical process will make it happen. I am absolutely certain of this.

This is a matter of understanding and morality. I'm sure that hydropower engineers, for example, are well aware of the cost and economic effect of building a power facility, as well as its negative impact. It is a matter of choice and morality. It is hard for me to believe that parliamentarians and people in ministries do not understand this. Sooner or later, whether in 20, 30, 100, or 300 years, we will come to this realization. We need to convey to the public, to the people, and to the politicians: let's not waste time. Let's do it consciously right now—organize roundtables, discuss, calculate, and work towards a solution.

7.3. Preliminary conclusions

Reflecting on the different arguments mentioned above, taking into consideration the ongoing discussions in policy and research circles, but also reflecting on our own study of the Dnipro River outlined in the first parts of this report, brings us to a point where we are rather hesitant about the intention to rebuild the dam.

With the information available at this moment, Ro3kvit and Greenpeace advice not to rebuild the dam in its pre-war form, but to start rethinking the relevance of the dam in the current conditions.

The decision to rebuild or not to rebuild the dam depends on a wide array of variables, and from the information available today, we believe that the justifications provided are not convincing enough to explain the need for reconstructing the dam in the current realities. In delivering such projects, it is imperative to establish extensive valuation assessments that take into account the different limitations and advantages, as well as to engage with various stakeholders to develop various alternative scenarios. To date, we have not seen sufficient effort to conduct such an evaluation.

This does not mean that the possibility of rebuilding the dam should be rejected once and for all. Such a possibility should be considered among other alternatives, but any decision that is seriously considered must be based on a robust base that can guarantee the delivery of its set objectives, including the financial viability, accounting for potential risks and threats, but involving relevant stakeholders in the decision-making process. To analyse the potential of the different scenarios, Ukraine is inevitably facing the limitations of insufficient data, as well as the danger of war.

There is a need to find and design new balanced solutions for a healthy, future-proof river and economy based on deeper on-site research, debates and discussions.

Ultimately, the decision on which reservoir is needed for the people of Ukraine, for the country's economic development and for the preservation of natural systems must (we believe) be made with the consideration of the interests and needs of all users of this vital resource – local populations, farmers, energy producers, industrial actors, the country's national security interests and more. It should also be done with the involvement of knowledge and expertise from Ukraine and abroad, considering the broader systemic challenges related to the dams: the modernisation of water technologies for agriculture, the decentralisation and modernisation of the energy system, the preservation of ecosystems and biodiversity, and the broader issues related to both the war and climate change.

We hope that this report will also be useful for future discussions and decision-making and invite all stakeholders and actors to continue researching and discussing this important question.

Last but not least, there is a good chance the Kakhovka dam will be an example and maybe even a symbol of recovery debates in Ukraine. We believe that good discussions, research and logically integrated arguments will lead to an inspiring and future-looking approach. The discussion on the Kakhovka dam will be a symbol for the recovery of Ukraine. A choice between building backwards or building back better. In conclusion, we encourage you to look at the situation from a new perspective without the pressing and urgent need to rebuild.

While neither desired nor planned, the terrorist destruction of the Kakhovka dam can be viewed as an opportunity to rethink how we interact with the river more broadly.

Part 8
Action Plan

Contents

Summary

This chapter offers concrete recommendations and strategies that are intended to facilitate and support various stakeholders (local, regional, and national) in dealing with the processes linked to the management of rivers and waterways of the Dnipro River basin. Below, we reflect on world practices for coordinated planning, sustainable water management, integration and collaboration of stakeholders and initiatives, determining and evaluating objectives, goals and priorities, the role of river basin organisations in water management and the various forms of RBOs. We also suggest a list of steps that may be useful in delivering set objectives and securing the support of international financing institutions. Ultimately, we stress the importance of adhering to participative approaches and engage with local stakeholders at the different stages of river/water management.

8.1. A vision for coordinated planning

8.1.1. Planning for Sustainable Water: Transforming Practices for Resilient Communities

Introduction: Planners play a pivotal role in reshaping water systems and resources to achieve sustainability and resilience goals. The need to address severe and unpredictable water management issues is driving progress at both local and broader scales. This summary explores two strategic planning frameworks: APA's *Five strategic points of intervention* and the *Sustaining Places initiative*, to improve water planning and management.

Water and Strategic Points of Intervention: Planners operate in key areas such as visioning, plan-making, standards, policies, development work, and public investments. However, recognizing strategic points of intervention is essential. While planners often lead in visioning and development work, collaboration with various water professionals is crucial for effective water management. Planners must align with hydrologists, engineers, landscape architects, scientists, economists, and legal experts to ensure sustainable water management.

Water in the Context of Sustaining Places: APA's Sustaining Place initiative introduces a paradigm shift toward integrated sustainability. It offers principles, processes, and attributes for plan-making standards, accompanied by best-practice actions. These standards help planners integrate water issues into their work, fostering more sustainable water management practices.

Recommended practices: Innovative approaches, alliances, and interdisciplinary strategies are continuously evolving in water capital planning, operation and management. The principles of One Water management, emphasizing adaptability and collaboration, serve as a foundation for sustainable practices. Planners, collaborating with water professionals, must address water supply, wastewater, and stormwater practices (see Table 1).

8.1.2. A Vision for Coordinated Planning

Transforming water management practices requires planners to collaborate across disciplines, embrace innovative approaches, and integrate sustainability into their work to expand the value and effectiveness of capital improvements, which can be challenging to fund. The outlined frameworks and recommended practices empower planners to play a crucial role in building resilient communities with sustainable water systems. According to the Water Research Foundation's (WRF) *Coordinated Planning Guide: A How-To Resource for Integrating Alternative Water Supply and Land Use Planning* (2018), communities that have integrated land use planning and water planning processes report multiple benefits from the collaboration (see Table 2).

Table 1. Water Management Practices

• **Water Supply Practices.** Planners and water professionals contribute to water supply by coordinating with local providers to align water management plans with the government's vision. They ensure land-use plans support One Water management, protect traditional water resources, and address water supply in development proposals. Zoning and subdivision regulations play a crucial role, and planners must collect information on water resource availability for new developments.
• **Wastewater Practices.** Planners engage in conversations about innovative wastewater infrastructure, influencing growth patterns. They help decide where and when to expand municipal wastewater service, integrating sustainability goals into comprehensive plans. The field sees advancements in on-site and district-based nonpotable reuse, energy use in wastewater, and natural treatment systems.
• **Stormwater Practices.** Planners advocate policies to integrate stormwater best practices through comprehensive plans and development regulations. Emphasizing green systems over gray infrastructure, planners promote on-site capture, infiltration, and slow release of stormwater. Strategies like low-impact development and green stormwater infrastructure contribute to a more attractive and resilient urban environment.

Table 2. Benefits of integrated land use planning and water planning procesess

• Increasing water supply sustainability while lowering costs
• Resolving conflict between various land use plans, economic development plans, and regional/statewide water plans
• Managing competition for limited water supplies
• Facilitating protection of natural resources and cultural heritage
• Improving water management plans, data development, and data sharing
• Identifying early warnings of legal and other water vulnerability risks and uncertainties
• Addressing urban flooding by integrating low-impact development design into land use planning
• Providing better information for the public
• Increasing predictability within the development process
• Securing water supplies that are drought tolerant and independent of weather (e.g. recycled water)
• Enabling pursuit of additional community priorities (e.g. affordable housing or economic development) through more robust, holistic planning

Water stress is increasing in many parts of the world, including Ukraine, due to water supply shortages, population growth, water quality problems, and competing demands. As a result, more communities are looking to augment their current supplies with alternative water supplies. In these communities, most potable water comes from either fresh surface water or groundwater.

While a community's first priority should be to protect these existing supplies, there are many options for alternative supply to support growth and more sustainable water use. Alternative water supplies, however, may be obtained from a variety of sources, including conservation, stormwater capture, water reuse or recycling, and more advanced technologies like desalination or aquifer storage and recovery.

Alternative supplies are an important piece in the One Water puzzle, which aims to manage finite water resources for long-term resilience and reliability, meeting both community and ecosystem needs.

Because alternative water supplies help to diversify a community's water portfolio and can be a critical part of a sustainable and resilient water future, the need for collaboration extends beyond water utilities. Some alternative supplies, like rainwater capture and greywater, happen on-site and are installed and managed by owners and occupants rather than water providers.

Achieving the greatest success in developing alternative supplies as part of a community's water supply portfolio will require collaboration between land use and community planners to become more standard practice.

Methodology for Better Collaboration

The WRF planning guide provides a pragmatic, 10-step framework for better integration through collaboration initiatives that could be undertaken by multi-disciplinary teams of water and land use planning professionals, as summarized in Tables 3, 4, 5.

Table 3. Coordinate Long-Range Plans

1.	**Conduct Research**: Identify the alternative water supply types in use or available in your community and establish a baseline of information about them. Understand the challenges regarding the existing/future water supplies for your community. Also review state/local water and health laws for any pertinent requirements. Use this information and research to inform all next steps taking into account which land use planning activities are best suited to the alternative water supplies of interest.
2.	**Review Plans**: Review your community's comprehensive plan, capital improvement plan, and water management plans to see if/how alternative water supplies are addressed.
3.	**Align Projections**: Check on the sources for the land use planning population projections; compare against the population projections/sources used by water utilities. Population can be a first step to more in depth discussions about projections of the future, considering additional topics such as climate change and the economy, commercial/industrial/institutional customer trends, etc.

Table 4. Coordinate Codes and Regulations

4.	**Evaluate Regulations:** Evaluate your community's zoning, subdivision, and development regulations, as well as state laws and regulations, to see where there may be unintended barriers to implementing alternative water and/or One Water supply projects
5.	**Review Fees and Incentives:** Review fee structures and code requirements to see if there are any opportunities to incentivize or promote alternative water supply projects.
6.	**Integrate Ordinances:** Review any separately adopted water sustainability, environmental management, and environmental conservation codes/ordinances and see if there are ways to integrate them with zoning, subdivision and/or development regulations.

Table 5. Coordinate Development Review Processes

7.	**Clarify Review Processes**: Examine the steps in the development review process to see where/how water utilities can or should be more engaged. Formalize those opportunities for collaboration via steps or sub-steps in your development review process.
8.	**Build Teams**: Invite your water utility or community planner counterpart to a meeting to get to know them and explore opportunities for enhanced collaboration on alternative water supplies. If such a relationship already exists, expand your efforts to establish a multi-disciplinary team of water and land use planning professionals and set up a mechanism for routine coordination.
9.	**Inform Decision Makers**: Provide training or information to elected and appointed officials (especially those involved in land use approvals) about best practices for protecting existing water resources as well as alternative supply types, methods, options, and/or challenges in your community.
10.	**Revisit Inspection Procedures**: Review your community's inspection procedures and staffing assignments to ensure that inspections are happening at the right time(s) and that staff has sufficient training

Planning methodologies for Different Water Resources Objectives

URAG's Environmental Sustainability Planning Guidelines (sustainability.urag.org) provide easy to use, "how to" methodologies that local planners, government officials, and community groups can use to achieve different water resources objectives, outlined in Table 7.

Given its overarching relevance to the present Dnipro River Basin document, the guidelines for Planning for River Basins and Integrated Water Resources Management, as well as for establishing a River Basin Organization, are summarized in this document.

Table 6. Integrated Water Resources Management (IWRM) – Contents

• Standards and Indicators for Integrated Water Resources Planning
• Planning for River Basins and Integrated Water Resources Management
• Planning Land and Water Management for Watersheds
• Planning Green Infrastructure to Manage Stormwater
• Planning Water Conservation to Address Water Scarcity
• Planning Drinking Water and Wastewater Treatment
• Planning Equal Access to Clean Water and Sanitation

Planning for River Basins and Integrated Water Resources Management

The River Basin IWRM Planning Process. The Global Water Partnership (GWP) provides a platform where water actors at global, regional, national, and local levels can share water insights and access technical assistance and policy guidance for the smart management of water resources. GWP has produced a comprehensive guide to integrated water resources management (IWRM) planning: *"Integrated Water Resources Management Plans, Training Manual and Operational Guide*", March 2005. The guide covers all aspects of IWRM and river basin planning, from data collection and analysis to stakeholder engagement and implementation. It reflects the IWRM methodology promoted by the World Bank and other international development aid institutions.

Integrated Water Resources Management (IWRM) is a process that promotes the coordinated development and management of water, land, and related resources in order to maximize the economic and social benefits in an equitable and sustainable manner. IWRM plans are developed through a series of steps outlined in Table 8. The content of the River Basin IWRM plan should include the elements outlined in table 9. Moreover, the IWRM planning process should be iterative and adaptive, and it should be based on the principles of stakeholder participation, integrated water resources management, and sustainable development.

Table 7. Integrated Water Resources Management (IWRM) – Main Steps

• **The initiation phase** involves getting government commitment, forming a team, and identifying the expected outputs of the planning process. This phase is crucial for establishing the foundation for the IWRM plan and ensuring that it is aligned with the overall goals and objectives of the government.
• **Developing the Work Plan.** The work plan outlines the specific tasks and activities that will be undertaken during the IWRM planning process. It also includes a timeline for completing these tasks and activities, as well as a budget for the planning process. The work plan should be developed in consultation with stakeholders to ensure that it is realistic and achievable.
• **Establishing the Strategic Vision.** The strategic vision articulates the desired future state of water resources management in the river basin. It should be based on a comprehensive understanding of the current situation and a clear articulation of the long-term goals for the basin. The strategic vision should be developed in a participatory manner, involving stakeholders from all sectors and levels of government.
• **Situation Analysis.** The situation analysis involves collecting and analyzing data on the current state of water resources in the river basin. This includes data on the physical, social, economic, and environmental aspects of the basin. The situation analysis should be conducted in a rigorous and transparent manner, using sound scientific methods.
• **Water Management Strategy Options Identified.** This phase involves identifying and evaluating different options for managing water resources in the river basin. The options should be considered in light of the strategic vision and the findings of the situation analysis. The evaluation of options should consider the economic, social, environmental, and institutional feasibility of each option.
• **Water Management Strategy Options Identified.** This phase involves identifying and evaluating different options for managing water resources in the river basin. The options should be considered in light of the strategic vision and the findings of the situation analysis. The evaluation of options should consider the economic, social, environmental, and institutional feasibility of each option.

Table 8. Integrated Water Resources Management (IWRM) – Contents

• A vision for the future of water resources management in the river basin.
• A situation analysis of the current state of water resources in the basin.
• A strategy for managing water resources in the basin.
• An action plan for implementing the strategy.
• A monitoring and evaluation plan for tracking progress, making adjustments to the plan as needed

Establishing a River Basin Organisation (RBO)

For River Basin IWRM planning to be effective, some form of organization needs to be established to oversee the planning and implementation process. Several types of river basin organizations (RBOs) have evolved or been developed deliberately over time to provide river basin planning and management services (see Table 10)

RBOs were originally set up to plan and manage for a single water-related purpose, such as water supply or hydropower, or a single project with multiple water-related purposes. The RBO typically had a limited role, and the planning they did rarely addressed the overall sustainable management of the river basin.

Conflict and disagreement often resulted when different single-purpose RBOs pursued their individual water resources agendas, especially when considerable resources had already been expended in making and implementing their river basin plans. Mixed results in effectively implementing RBDMP can often be traced to insufficient RBO power to carry our RBDMP.

The river basin planning goals of RBOs vary depending on the particular RBO. Table 11 provides examples of the most relevant and common objectives behind RBOs. Given the above objectives and purposes of a river basin organization, a number of topics should be addressed in a RBO plan (see Table 12). For each of these RBO design characteristics, information was gathered for each RBO in the world's transboundary rivers.

Authors: Susanne Schmeier, Andrea K. Gerlak, and Sabine Blumstein. International Journal of River Basin Management, Volume: 13, Issue 1, pages 51-72, 2015.

Table 9. Types of River Basin Organisations (RBOs)

• Autonomous regional authorities – have power to promote and enforce change
• Entities – e.g., development corporations, which have intermediate and varying power
• Planning executives
• Coordinating commissions or committees – advisory or monitoring roles only

Table 10. River Basin Organisation (RBO) – Goals

• To coordinate the use of shared basins (multi-users/inter-state/inter-nation).
• To avoid environmental degradation.
• To promote sustainable development.
• To integrate land and water management.
• To promote integrated, optimal development of natural resources, agriculture, infrastructure etc.
• To provide comprehensive and decentralized management and planning.
• To decentralize planning and management and make it adaptive.
• To ensure developments within a basin do not interact in a negative way.
• To focus natural resource benefits for regional development and serve as a regional planning and management strategy.
• To attract development into a remote area, countering the "pull" of large cities or favored areas.
• To promote rural development.
• To provide an acceptable management and planning approach that might "side-step" existing stagnant or corrupt arrangements.
• To establish a politically acceptable way of gaining the cooperation of co-riparian states or nations which would probably refuse to surrender authority to other types of agencies.
• To integrate environmental dimensions with other aspects of planning and management.

Table 11. River Basin Organisation (RBO) – Topics to be addressed

1. The membership structure
2. The functional scope
3. The international water law principles on which the RBO relies
4. The level of institutionalization and legalization of the RBO
5. The RBO's organizational set-up
6. The Secretariat
7. Thefinancing of the RBO
8. Decision-making mechanisms
9. Monitoring mechanisms
10. Dispute resolution mechanisms
11. Mechanisms for stakeholder involvement

8.2. Action Plan

Guidance for Preparing a Project Concept Note for Submission to International Financing Institutions

In order to develop and implement a river basin plan and river basin organization, the Water Agency and/or Ministry of Environment and Natural Resources may decide to seek funding and/or financing from an international financial institution, including multilateral development banks like EBRD, UNDP or the World Bank. In such an instance, the outline in Table 13 provides the recommended content of a Project Concept Note that could serve as a starting point in seeking monies for this initiative.

Table 12. Recommended Content for a Project Concept Note

Executive Summary	• Briefly summarize the proposed project, its objectives, and its potential impact.
Project Background and Context	• Describe the problem or challenge that the project seeks to address. • Discuss the relevance of the project to the World Bank's goals and objectives. • Outline the country's development context and the project's alignment with national priorities.
Project Objectives	• Clearly state the overall objective of the project. • Identify specific, measurable, achievable, relevant, and time-bound (SMART) objectives.
Project Design and Methodology	• Describe the project's design, including its components and activities. • Explain the project's methodology, including data collection and analysis methods. • Outline the project's implementation plan, including timeline, budget, and staffing arrangements.
Potential Impact	• Assess the potential impact of the project on the target beneficiaries and the broader community. • Quantify the expected impacts whenever possible. • Align the project's impact with the World Bank's Sustainable Development Goals (SDGs).
Risks and Mitigation Strategies	• Identify potential risks that could affect the project's implementation or impact. • Develop strategies to mitigate or manage these risks.
Financing and Budget	• Provide a breakdown of the project's budget, including sources of funding and cost allocation. • Explain the cost-benefit analysis of the project. • Justify the requested funding from the World Bank.
Institutional Arrangements and Coordination	• Describe the institutional arrangements for project implementation, including roles and responsibilities. • Outline the coordination mechanisms with stakeholders, including government agencies, civil society, and the private sector.
Monitoring and Evaluation	• Define the project's monitoring and evaluation framework, including indicators, data collection methods, and evaluation frequency. • Explain how the monitoring and evaluation findings will be used to inform project implementation and decision-making.
Conclusion	• Reiterate the project's significance and its potential contribution to development outcomes. • Express appreciation for the World Bank's consideration and support.

8.3. A participative approach

8.3.1. Looking back: a process of collecting

This research has been done with the help of many partners in Ukraine. A basic level of participation took place by conducting the interviews. During these interviews, and during the research in general, we felt how much Ukrainian people are connected to the Dnipro.

This became even more clear when the partners from Kharkiv School of Architecture (Ukraine), Umeå University, School of Architecture (Sweden), University of Limerick (Ireland), and Warsaw University of Technology Architecture Department (Poland) did a two-week workshop about it, with the financial support of the Norwegian Refugee Council and the support of Arup, Egala and Ro3kvit. Results can be seen in www.kharkiv.school.

The attraction of the Dnipro River is huge, and all people have their own connection. But besides being attracted, many people are worried. These people deserve to be heard, included in the debates and talks. And their opinion on priorities of different topics should be strongly taken into account by decision makers and donors.

8.3.2. Looking forward to share

This Dnipro River Vision is an inspirational document that shows the potential that can be discussed, debated and understood. We are looking for partners and donors to support us in the communicative approach. In this process, we need to find out what part of the inspiration of perspectives is being felt the most promising. That will give input and focus to the next research questions.

We chose to make this document to inspire and to show the unused potential. Many stakeholders can use elements of it. In chapters 8.1 and 8.2, we shared our vision of the next steps in the process and the action plan. Besides that, we would like to share and discuss this vision and approach itself because more communication and participation are needed. We are not aiming for a quantitative approach to participation or communication but a qualitative one.

We hope to generate awareness around it by sharing the results, the ideas, and the visions we have. We believe that a lot of people in Ukraine can be reached in forums, exhibitions, and lectures (online and offline) to get feedback. This will strengthen our recommendations and the directions for deeper research and will give us focus to prepare for the next steps. We would love to be invited to forums, conferences, events, public meetings, and inspirational talks. We hope to see you there!

8.3.3. Formal input on the Dnipro River Basin Management Plan

Besides inspiration, this document should influence the development of formal government documents. Ro3kvit and Greenpeace shared their input as public feedback for the Water Management Master Plan by the Water Agency for further approval by the Cabinet of Ministers of Ukraine. The projects for the Master plan were described as follows:

Table 13. Project ideas for the Dnipro River Basin Management Plan

1.	**Development of Principles for the Reuse of Treated Wastewater:** Develop and implement principles for using treated wastewater for industrial and agricultural needs to efficiently utilize resources and reduce environmental impact. Prohibit water intake from the Dnipro basin when sources of treated wastewater are available to conserve water resources and reduce the burden on the river system.
2.	**Study of the Impact of the Russian War on the Dnipro Reservoir Cascade and Future Options for Sustainable Water Supply in Ukraine:** Conduct a multidisciplinary analysis of the war's impact on the Dnipro reservoirs and identify future options for sustainably meeting the long-term needs of the population, economy, and environment, including evaluating best water resource management practices under significant climate change and flood protection conditions.
3.	**Study of the Load and Resilience of Industrial and Energy Facilities Requiring Cooling, and Development of Residual Heat Utilization Principles:** Conduct a comprehensive analysis of the reliability and load of industrial enterprises, nuclear and thermal power plants on river ecosystems under increasing frequency of floods and droughts, water stress, rising river water temperatures, and significant reductions in flow and water levels due to climate change. Develop and implement practices for using residual heat from heavy and light industry, treatment facilities, sewer networks, data centers, landfills, commercial, and other facilities to reduce energy consumption, carbon footprint, and thermal load on rivers.
4.	**Development and Implementation of Biodiversity Conservation Measures in the Dnipro River Basin:** Develop and conduct a comprehensive analysis of biodiversity and the natural environment in the Dnipro River basin with the involvement of experts and scientific organizations. Identify major threats and factors affecting biodiversity in the Dnipro River basin, such as water pollution, habitat loss, and invasive species. Develop a biodiversity conservation strategy, including setting specific goals and objectives for nature conservation within the framework of the Dnipro River Basin Management Plan.

8.3.4 Participation steps

At the moment of launching this report, the joint team of Ro3kvit and Greenpeace envisages different formats and opportunities for public involvement in the process of creating strategies for the future of the Dnipro River. On the one hand, the concept of participation can be seen in terms of direct, indirect involvement of individuals or communities in formal decision-making procedures.

On the other hand, the concept of participation can also envisage other formats of interaction. At the initiative of the urban coalition Ro3kvit and APA-URAG, a handbook on public participation in urban planning processes in the context of Ukraine was created. It is available on our website at www.ro3kvit.com. The handbook provides recommendations on various tools and means of public participation in the urban planning process, so we recommend that you read it in more detail.

Below we have highlighted four main principles that were followed during this study and invite you to learn more about them. We look forward to receiving your comments and feedback and will be happy to consider proposals for further cooperation!

1. Receive feedback about this vision

One of the basic rules in participation: ask a question. So that is what we do. Please send us your feedback. We are interested in understanding how this report is received, how it can be improved, and how next steps can be built on top of it. Please join us in one of our public events, lectures or exhibitions that we hope to organise in 2024 (as time and safety allows it). But feel free to leave comments on the website or via

office@ro3kvit.com
Subject: Feedback Dnipro River

2. Develop a participation process on national scale

Connected to the vision for coordinated planning (as described in 8.1 and 8.2) a participation process should be developed and formalised. In this, major influence in focus and decisions will be prepared, to be decided in the national parliament.

In this, major influence in focus and decisions will be prepared, to be decided in the national parliament. The participation process should be transparant and include principles that can be discussed and voted, also with little technical background.

3. Support decision making

On a local level, all around the Dnipro River and the Dnipro Basin, the knowledge of Dnipro River can be expanded. If requested, we can support in this awareness and knowledge campaign. Or we could consult on specific topics of research, projects or design.

4. Take initiative

Participating also means doing, or acting. Because within the boundaries of the law, based on the principles and guidelines as described in this report, we believe a lot of initiatives can just simply take place. Websites with pictures, explorative tours with friends, children playing in the water, local tests of water quality, books with stories... initiatives that help to connect to the land, the water and the identity.

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The Dnipro River is inseparable from Ukraine.
Ukraine is incomplete without the Dnipro River.

This vision is a combination of research, ideas and scenarios that explore the opportunities for the future of Ukraine's grand Dnipro River. How exactly we can reach this future remains open for discussion. But the potential is definitely there and we hope that this book will help to bring it to life.

This "Integrated Vision" explores different topics, or as urban planner like to call them – layers. By discussing and connecting these different layers we identify the possible positive and negative impacts that our various interactions with Dnipro River can have. This vision also connects different scales, from the river to the river basin, from the local context to the national, regional or even global contexts. Ultimately, this vision addresses different topics and different stakeholders, with the objective to find balanced and future-proof solutions for the future of the Dnipro River and Ukraine.

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