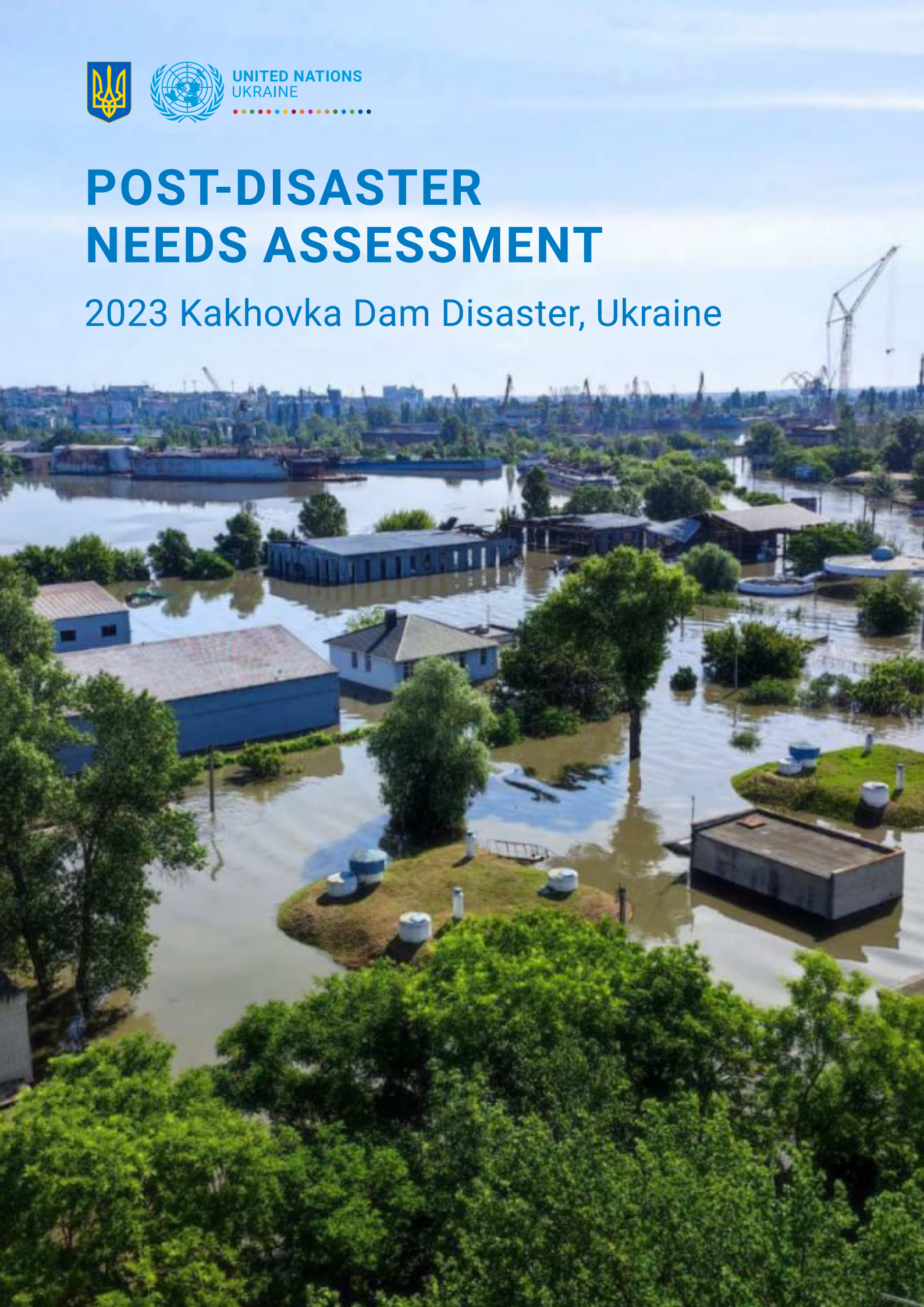
UNITED NATIONS
UKRAINE

# POST-DISASTER NEEDS ASSESSMENT

## 2023 Kakhovka Dam Disaster, Ukraine



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Front (and back) cover: The main sewage pumping station flooded after the Kakhovka dam destruction in Korabel micro-district. Credits: Kherson Vodokanal staff

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **BBB** | Build Back Better |
| **BOD** | Biological Oxygen Demand |
| **CCI** | Cultural and Creative Industries |
| **CHPP** | Combined Heat and Power Plant |
| **ERCC** | Emergency Response Coordination Centre |
| **EU** | European Union |
| **FAO** | Food and Agriculture Organization |
| **GCA** | Government Controlled Areas |
| **GDP** | Gross Domestic Product |
| **GoU** | Government of Ukraine |
| **HA or ha** | Hectare(s) |
| **HeRAMS** | Health Resources and Services Availability Monitoring System |
| **HPP** | Hydroelectric Power Plant |
| **IAEA** | International Atomic Energy Agency |
| **ICH** | Intangible Cultural Heritage |
| **IDP** | Internally Displaced Person(s) |
| **IOM** | International Organization for Migration |
| **IRENA** | International Renewable Energy Agency |
| **JRC** | Joint Research Centre |
| **KSE** | Kyiv School of Economics |
| **kV** | Kilo Volts |
| **MSME** | Micro, Small and Medium-Sized Enterprises |
| **MW** | Mega Watts |
| **NBU** | National Bank of Ukraine |
| **NEURC** | National Commission for State Regulation of Energy and Public Utilities (National Energy and Utilities Regulatory Commission) |
| **NGCA** | Non-Government Controlled Areas |
| **NPP** | Nuclear Power Plant |
| **O&M** | Operation and Maintenance |
| **PDNA** | Post Disaster Needs Assessment |
| **PEEN** | Pan-European Ecological Network |

| | |
|---|---|
| **PV** | Photo Voltaic |
| **RCCE** | Risk Communication and Community Engagement |
| **RDNA** | Rapid Damage and Needs Assessment |
| **RES** | Renewable Energy Systems |
| **SES** | State Emergency Service |
| **SME** | Small and Medium-Sized Enterprises |
| **SPP** | Small Power Producers |
| **TB** | Tuberculosis |
| **TWh** | Terawatt-hour |
| **TPP** | Thermal Power Plant |
| **UAH** | Ukrainian Hryvnia (currency) |
| **UN** | United Nations |
| **UNDP** | United Nations Development Programme |
| **UNEP** | United Nations Environment Programme |
| **UNESCO** | United Nations Educational, Scientific and Cultural Organization |
| **UNHCR** | United Nations High Commissioner for Refugees |
| **UNOSAT** | United Nations Satellite Centre |
| **US** | United States of America |
| **US$ or USD** | United States Dollars |
| **VET** | Vocational Education and Training |
| **WB** | World Bank |
| **WHO** | World Health Organization |
| **WPP** | Wind Power Plants |
| **WSS** | Water Supply and Sanitation |
| **ZNPP** | Zaporizhzhia Nuclear Power Plant |
| **ZTPP** | Zaporizhzhia Thermal Power Plant |

# ACKNOWLEDGEMENTS

The Post Disaster Needs Assessment report of the Kakhovka Dam Disaster was jointly prepared by the Government of Ukraine and the United Nations. The report benefitted from inputs provided by the World Bank Group (particularly through the GRADE assessment), the European Union, Food and Agriculture Organization (FAO), International Labor Organization (ILO), International Organization for Migration (IOM), the United Nations Children's Fund (UNICEF), the United Nations Development Programme (UNDP), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), the United Nations High Commissioner for Refugees (UNHCR), World Health Organization (WHO).

On the part of the Government of Ukraine, the PDNA was led by the Ministry of Economy. All relevant line ministries have participated in the assessment, with extensive support from the Kyiv School of Economics (KSE) for data provision and analysis.

This publication benefitted from data provided by EMITTER project, which is realized under the financial support of the European Union. Its contents are the sole responsibility of the project and do not necessarily reflect the views of the European Union.

The sector-wise chapters of the report were authored by teams consisting of national and international UN experts and their Government of Ukraine counterparts, with technical support and guidance provided by UNDP. The final report, including the Executive Summary, Introduction, and Recovery Framework and Strategy, was compiled and edited by the UN Resident Coordinator Office (UNRCO)'s core team and an international expert.

Annex 1 includes a list of all contributors.

# FOREWORD

The destruction of the Kakhovka Dam on 6th June 2023 is another devastating consequence of the Russian invasion of Ukraine. The breach led to extensive flooding, impacting 80 settlements across four oblasts: Kherson, Mykolaiv, Dnipropetrovsk, and Zaporizhzhia. Approximately 100,000 residents were directly affected by the resulting deluge. The destruction of the dam also disrupted critical aspects of life in southern Ukraine, including energy production, access to drinking water, irrigation, and river transport. It left a trail of damage in housing, infrastructure, the environment, and cultural heritage.

The Government of Ukraine and the United Nations carried out a Post Disaster Needs Assessment (PDNA) to evaluate the extent of the damage and losses incurred due to the dam's destruction. The assessment adhered to internationally recognized methodologies. However, conducting on-ground assessments was hindered due to a significant portion of the affected area being under the temporary control of the Russian Federation.

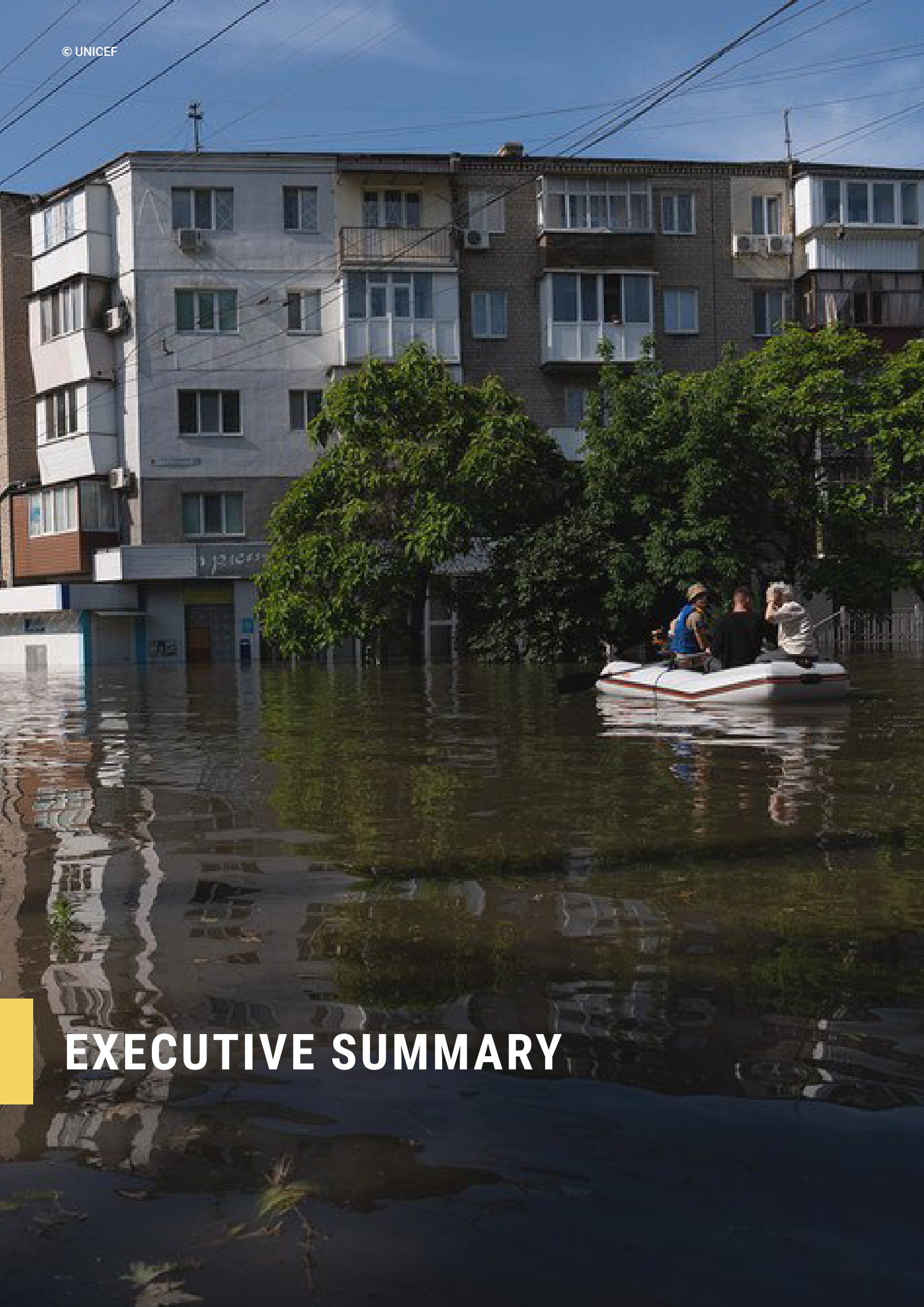
The PDNA findings indicate that there was approximately $2.79 billion in direct damage to infrastructure and assets, with losses exceeding $11 billion, with a particularly long-lasting environmental impact. The energy and housing sectors were hit the hardest in terms of direct damage, with the energy sector suffering $1.26 billion in losses and housing damage amounting to over $1.1 billion. Environmental and energy sectors also recorded the highest losses, which are vital for long-term stability and recovery.

Based on a "Build Back Better" approach, the PDNA estimates the total recovery and reconstruction needs to be approximately $5.04 billion, with $1.82 billion required in the immediate/short-term. The report puts forth suggestions for addressing the short-term needs in 2023-24, and for tailoring the response to meet recovery and reconstruction needs over the medium and long term, spanning the next ten years until 2033.

In the short term, addressing the needs of vulnerable populations must remain a priority. Looking ahead to the medium and long term, the report lays a solid analytical foundation for crafting a comprehensive financial and operational plan to support Ukraine's recovery and reconstruction efforts.

In the upcoming planning phase, it is essential to assess and prioritize investments, evaluate funding availability, and ensure optimal efficiency and coordination to concurrently address immediate needs, repair community assets, and tackle infrastructure requirements. This multifaceted approach involves reinstating critical utilities like electricity and gas supply to residential areas and essential infrastructure, providing housing solutions, extending financial, technical, and logistical support to revitalize key economic sectors, and restoring municipal, social, and healthcare services. These measures will not only facilitate the return of displaced individuals but also revitalize critical economic activities, safeguard vulnerable populations, and facilitate the implementation of preventive measures to protect environmental and cultural assets.

**Government of Ukraine** **United Nations in Ukraine**



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# EXECUTIVE SUMMARY

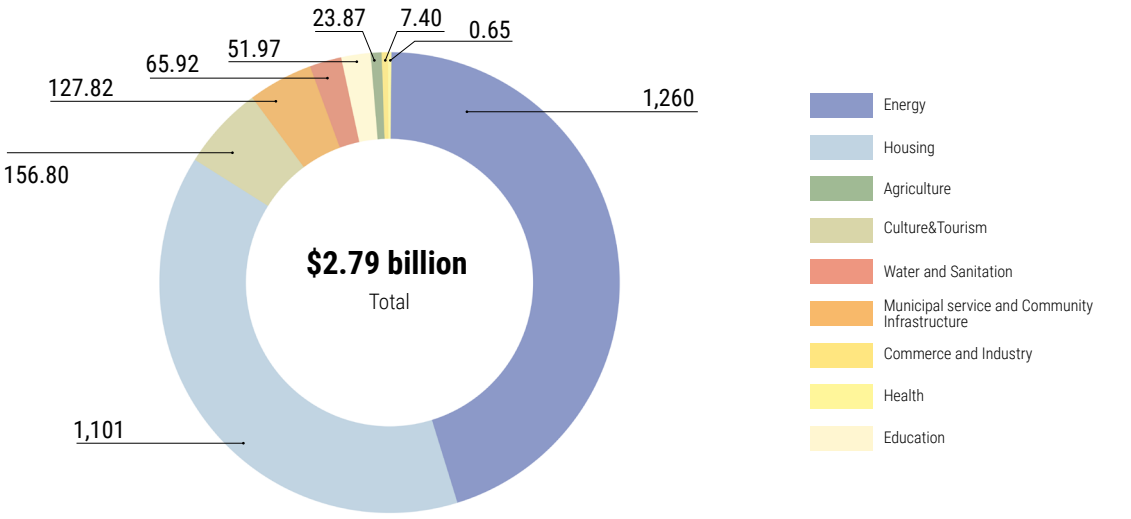
On 24 February 2022, the Russian Federation began a full-scale invasion of Ukraine. According to the RDNA 2, this caused US$135 billion in direct damage to buildings and infrastructure and generating reconstruction and recovery needs of over US$411 billion[1]. The destruction of the Kakhovka Dam on 6th June 2023 added to the devastating consequence of this invasion. The reservoir provided energy, drinking water, irrigation, and river transport in southern Ukraine. The breach flooded downstream communities and deprived upstream communities of water, necessitating urgent evacuations and humanitarian aid. The abrupt release of over 18 cubic km of water in a 4-day period, led to the loss of over 14.7 cubic km of water contained in the dam and affected 80 settlements in four oblasts—Kherson, Mykolaiv, Dnipropetrovsk, and Zaporizhzhia—impacting 100,000 residents directly. Up to a million people lost access to drinking water, and 140,000 were deprived of electricity. Protected and Forested Areas suffered massive environmental damage. The dam disaster and consequent floods exacerbated the impacts of the ongoing war. Some of the worst affected areas are on the left side of the Dnipro River in Kherson Oblast, under the temporary control of the Russian Federation, impeding the assessment of the full impact.

The Post Disaster Needs Assessment of the Kakhovka Dam Disaster, carried out by the Government of Ukraine and the United Nations in Ukraine, with the technical advice of UN entities and experts of the KSE, adopts the UN-EU-WB methodology. The assessment focuses on the disaster-affected areas and examines the damage to physical assets, indirect impact on economic activities, additional expenses caused by the breach, the immediate reconstruction and recovery needs, and the social and economic needs of the affected communities.

**The PDNA estimates US$2.79 billion of direct damage to infrastructure and assets and over US$11 billion of losses, the lasting environmental impact being the biggest concern. The direct damage to infrastructure and assets was highest in the energy and housing sectors (Figure 1).**

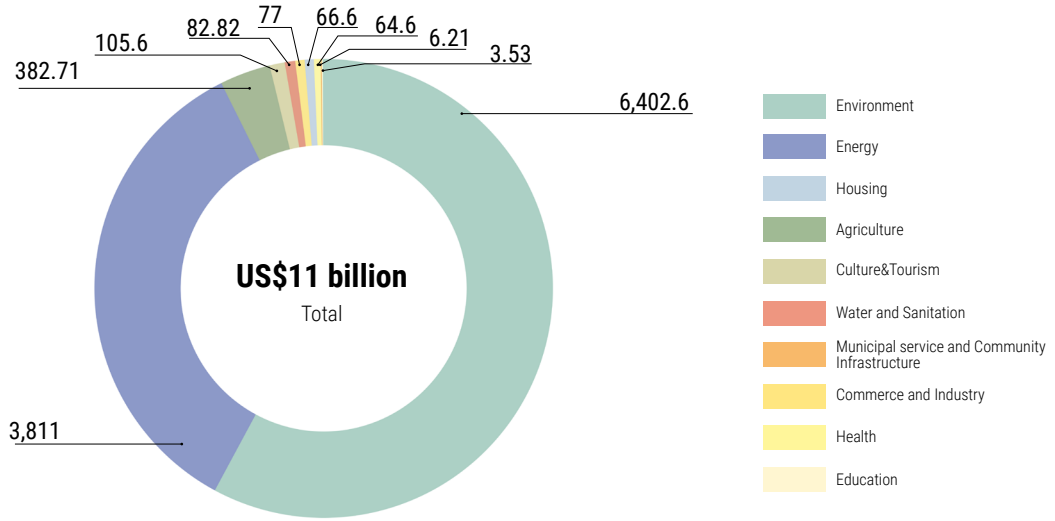
**Losses were highest in the environment and energy sectors (Figure 2), critical to long-term stability and recovery.**

**Figure 1:**
Damage by sector
(US$ millions)




1. The second Rapid Damage and Needs Assessment (RDNA2) published by the Government of Ukraine with its international partners in March 2023

**Figure 2:**
Loss by sector
(US$ millions)




**The PDNA estimates, on a Build Back Better basis, total recovery and reconstruction needs of US$5.04 billion, of which US$1.82 billion will be required in the immediate/ short-term (2023-24).**

**Figure 3:**
Total recovery needs by sector
(US$ millions)

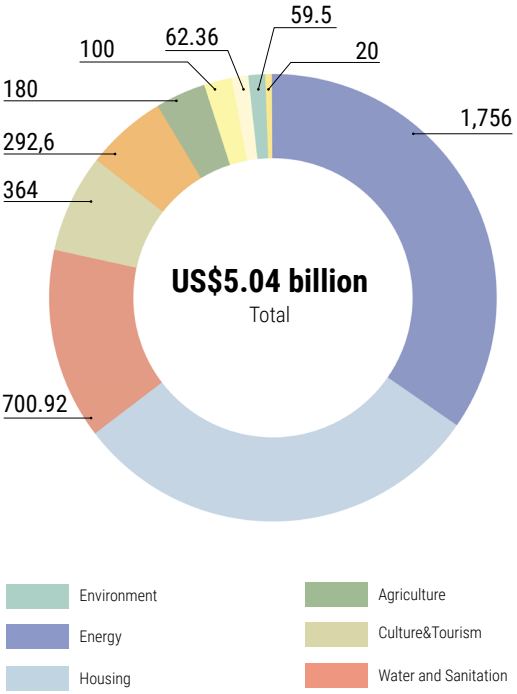
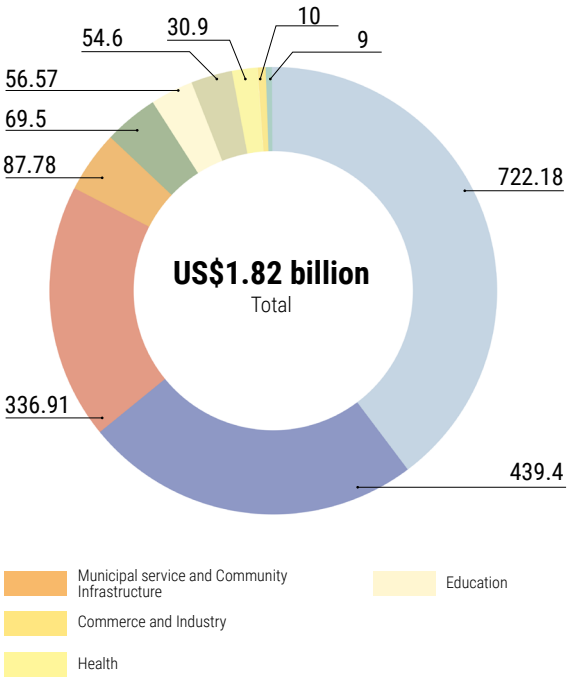



**Figure 4:**
Immediate/short-term recovery needs
by time period 2023-2024 (US$ millions)




**The Kakhovka dam breach wreaked environmental havoc, submerging 620 km², impacting 333,000 ha of protected areas and 11,294 ha of forested areas, altering river morphology, causing chemical pollution, and habitat destruction.** The PDNA estimates over US$6.4 billion in ecosystem service losses (58% of all losses) due to the impact on protected areas and forests. US$59.5 million will be required to recover from the environmental impact, with priorities including de-mining, cleanup, surveys, and contaminated site assessments. Some ecological impacts are irreversible and may have cascading effects in other sectors for decades.

**After the environment, the most intense impacts were on the energy infrastructure and housing.** With the irreparable destruction of the Kakhovka Hydroelectric Power Plant (HPP) alone costing US$1.2 billion, the total damage to the energy infrastructure crossed US$1.26 billion. The HPP destruction also caused revenue losses of US$96 million for the state-owned JSC Ukrhydroenergo, while the estimated income losses of the company due to the loss of electricity and ancillary services sales amounted to US$138 million (based on annual average[2]). The Kakhovka Reservoir was critical for the cooling systems of the Zaporizhzhia Nuclear Power Plant (ZNPP), Ukraine's largest nuclear power plant. The dam breach and drainage of the reservoir put the operation of the ZNPP at risk. This implies that the operator of the ZNPP, the state-owned Energoatom, might have a revenue loss of over $US3.6 billion.

Over 37,000 homes—mostly single-family houses in peri-urban communities and rural areas—were impacted by the flood, and 15% were damaged beyond repair, altogether causing US$1.1 billion worth of damage. Losses in the housing sector are estimated at US$66 million, mainly the cost of demolition and debris removal and the Government's one-time payment. This doesn't include bank losses, mortgage defaults, temporary rentals, or rental income losses.

The healthcare and education systems in the affected areas have also been seriously impacted, with several health facilities and 37 educational institutions damaged. Urgent actions to restore the continuity of health services and mitigate potential health risks are estimated to cause a loss of US$64.6 million. The healthcare system will need US$30.9 million in the first year and US$69.1 million in the medium to long term to restore services and recover from the disaster. The reconstruction and recovery of damaged education institutions is projected at US$62.37 million.

In addition to power supply, other services that sustain communities—drinking water, sewerage, solid waste management, and other municipal services—have all been disrupted by the dam breach. Water supply and sanitation (WSS) systems in the impacted areas, which had shortcomings before the disaster, suffered further damage (US$65.92 million) and losses (US$82.82 million) due to the flooding. The WSS sector needs US$700.92 million for recovery and reconstruction in downstream flooded areas and upstream areas with water shortages. Municipal facilities and equipment suffered damage to the tune of US$127.8 million. Debris removal costs and revenue losses of waste management entities add up to US$6.2 million. Municipal Services and Community Infrastructure require US$292.6 million to recover.

The dam breach impacted agriculture, fisheries, commerce, and industry, with consequences for the economy of the region. The agriculture sector has suffered damage worth US$406.6 million. The breach disrupted irrigation, causing crop production losses of US$376.7 million. The agriculture sector needs US$180 million over ten years to recover. Commerce and Industry in the region, already at a low because of the war, suffered US$7.4 million in damages and US$77.0 million in losses due to the dam breach. The impact on culture is also significant, including damage to archaeological sites and tourism facilities and losses to Cultural and Creative Industries as well as Intangible Cultural Heritage. This sector needs US$364 million to recover.

## Toward reconstruction and recovery

The proposed recovery framework for the Kakhovka Dam Disaster in Ukraine is segmented into three phases: Immediate/Short-term (2023-24), Medium-term (2025-30), and Long-term (up to 2033). A significant challenge is the limited access to non-government-controlled areas on the Dnipro River's left bank, affecting damage assessment and holistic recovery. The recovery must be integrated with Ukraine's broader strategy for post-invasion reconstruction, aligning with guiding principles from the Lugano Declaration and RDNA reports.

The immediate term focuses on enabling the return of displaced people, reviving key economic sectors, and protecting vulnerable groups. Essential services such as electricity and gas must be restored, and immediate actions must be taken to prevent further environmental and cultural asset damage. This phase requires an estimated $1.8 billion investment. The medium-term, with a $2.2 billion budget, is critical for reconstruction and centers on sectors like housing, energy, agriculture, and infrastructure. Principles like inclusivity and resilience are central at this stage. The long-term phase mainly targets the energy and culture sectors, requiring $1 billion.

Overall, the framework acknowledges the operational challenges due to ongoing hostilities and limited institutional capacities. Immediate fund allocation is recommended to enable the comprehensive planning required for this ambitious recovery effort. The resilience and determination of the Ukrainian people are vital for overcoming these challenges.

2. In addition, JSC Ukrhydroenergo estimates that financial damages from lost revenue due to loss of electricity and ancillary services sales could be higher by about US$828 million, since it will take at least 6 years before the Kakhovka HPP could be fully restored once the security situation allows for restoration of the HPP. Additionally, US$3.9 million (UAH147 million) will be spent by the company to provide additional service work on other affected HPPs along the Dnipro River canal system.



# INTRODUCTION

The Post-Disaster Needs Assessment (PDNA) of the destruction of the Kakhovka Dam, conducted by the Government of Ukraine and the United Nations in Ukraine follows the UN-EU-WB methodology for Rapid Damage and Needs Assessment (RDNA).

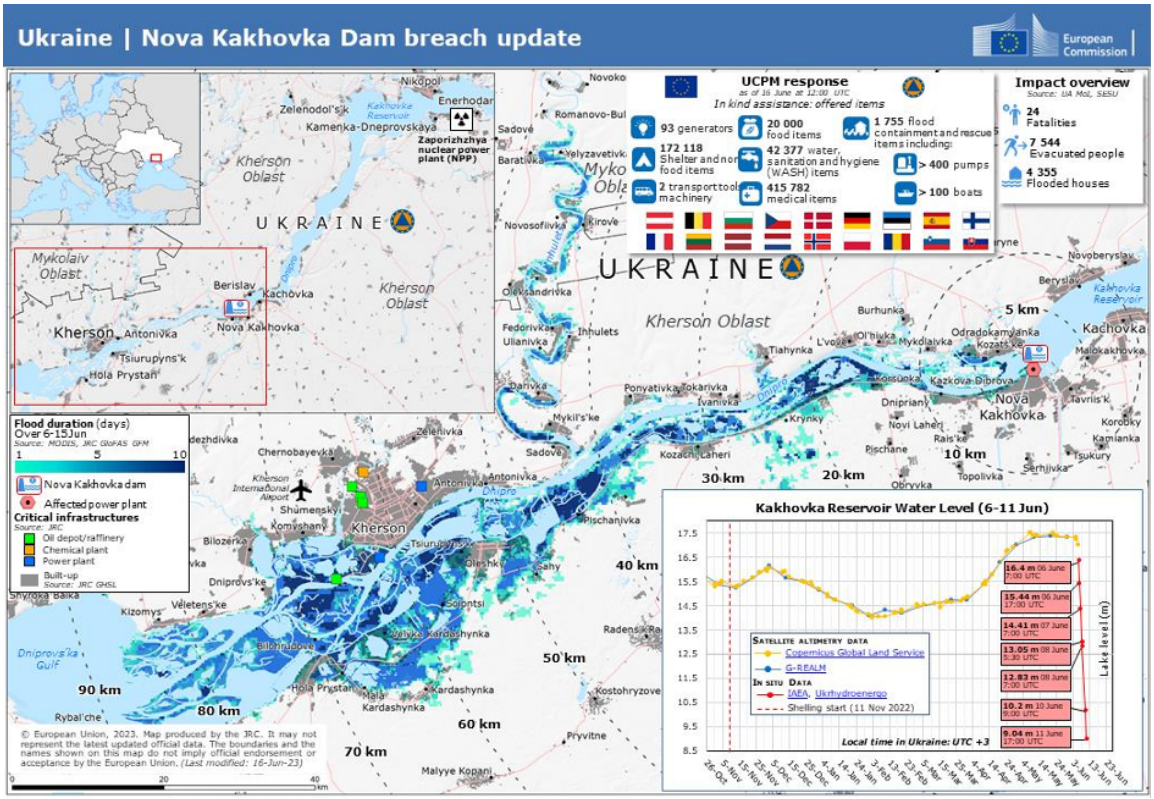
The figures presented in the PDNA add to the findings from RDNA 1 and RDNA 2, compiled as of June 1, 2022, and February 2023, respectively. According to RDNA 2, after one year of conflict, the direct damage has exceeded $135 billion, with economic disruptions and production losses totaling $290 billion. This figure does not fully capture the extensive human toll, including the loss of human capacity and the impending challenge of dealing with toxic remnants of ammunition and unexploded ordnance scattered across urban and rural areas, as well as critical agricultural land. As of February 2023, the current estimate for reconstruction and recovery needs stands at $411 billion.

The PDNA focuses on areas affected by the Kakhovka dam disaster. It assesses damage to physical assets, the indirect impact on economic activities, additional expenses arising from the breach, immediate reconstruction and recovery requirements, as well as the social and economic needs of the affected communities.

# Destruction of the Kakhovka Dam, its effects, and response

**Figure 1:** Map of the dam disaster impact as of June 12, 2023

Source: Emergency Response Coordination Centre, European Civil Protection and Humanitarian Aid Operations Link




The destruction of the Kakhovka Dam on 6th June 2023 is another devastating consequence of the Russian invasion of Ukraine. The breach inundated downstream communities and necessitated urgent evacuation and humanitarian aid. The Kakhovka reservoir was pivotal in supplying energy, drinking water, irrigation, and river transport to various southern Ukrainian regions and also provided water to industries in Kryvyi Rih, Nikopol, and Marhanets, among other cities and areas. Moreover, Kakhovka HPP and reservoir played a significant role in the socio-economic development of Ukraine, as it enabled the construction of Kakhovsky, North Crimean and Oleskandriisky canals, as well as Dnipro-Donbas, Dnipro-Inhulets, Dnipro-Kryvyi Rih canals, which were key to the uninterrupted drinking water supply to a number of oblasts, including Kherson, Mykolaiv, Dni-

propetrovsk, Donetsk and Zaporizhzhia. In addition, these canals provided water to the irrigation systems of southern and south-eastern parts of Ukraine. The abrupt release of over 18 cubic km of water within a 3-4 day period affected nearly 80 settlements in the Kherson and Mykolaiv regions, impacting around 100,000 residents directly. The effects included up to one million people losing access to drinking water, 140,000 being deprived of electricity and massive environmental damage in Protected and Forested Areas (Figure 1). Invaluable cultural assets were either destroyed or significantly damaged as a result.

The Government of Ukraine, local and regional authorities, supported by international partners and civil society, responded swiftly to the dam disaster to undertake evacuation and rescue operations. As of 17th July [3], 2,783 people had been evacuated, including 309 children and 80 individuals with limited mobility. There were 200 people in 10 temporary evacuation centers. 31 people were dead, 28 were injured, and the whereabouts of 41 individuals were unknown. The food supply for the population of 45 settlements in the territorial communities of Daryivska, Bilozerka, Tiahinska, Novokakhovska, Chornobaivska, Kalynivska, Novoronkovska, Mylivska, Novooleksandrivska, Berislavska, and Kherson was fully ensured. The provision of drinking water to residents in the Novovoronkovska, Novooleksandrivska, Mylivska communities, and the city of Berislav has been challenging. The administration has provided 257 tank carloads of drinking water. Water supply and sewerage systems are being cleaned, repaired and restored. Gas distribution and power supply systems are also being restored. As of July 17, over 12,000 metering points remained without power. The quality of water in River Dnipro is being monitored with laboratory testing of water samples. The presence of organic matter indicated by the biological oxygen demand remains a matter of concern. In addition, around UAH 845.1 million from state reserve is earmarked to Dnipropetrovsk, Zaporizhzhia, Mykolaiv and Kherson regional administrations to provide alternative water supply solutions (reconstruction/construction of canals, artesian wells, transportation of potable water). At the time of writing 70 artesian wells construction has been planned in these regions; 20 have already been constructed (15 in Dnipropetrovsk and 5 in Mykolaiv oblast), and construction has started on 3 artesian wells in Kherson oblasts.

A total of 13,157 affected individuals in the region are eligible for cash payments due to the destruction of the Kakhovka Hydroelectric Power Station. 8,008 have been registered at evacuation points, and 559.7 million UAH has been allocated for one-time financial aid of 5,000 UAH each. 3,362 applications for state aid have been received, and 2,104 are in the EISSS (Unified Social Information System) database. Additionally, 1,520 individuals will receive 6,600 UAH from sources outside the state budget. As of July 10, 2023, 3,022 residents have received nearly 20 million UAH from international organizations.

From the first day of the destruction, the humanitarian community, including the UN, international NGOs, national and local network of partners, were rapid to respond. They pre-positioned supplies in Kherson to respond with food and water. Within days, boats and amphibius vehicles were deployed by the World Food Programme to assist with deliveries to communities that had been flooded on the right bank of the Dnipro River, in addition to near-daily humanitarian convoys delivering supplies by road to the Khersonska, Mykolaivska, and Dnipropetrovska oblasts.

Since the destruction of the Kakhovka Dam approximately 85,000 people living in areas of Khersonska and Mykolaivska oblasts received humanitarian assistance. In addition, around 40,000 people were reached in Dnipropetrovska oblast, impacted by water shortages linked to the depletion of the Kakhovka reservoir. In total, the UN and its partners delivered 5.3 million litres of drinking water, nearly 2 million water purification tabs, and supported water treatment services and repairs in several communities or the Dnipro region. Partners distributed more than 200,000 rations of food, provided cash assistance to nearly 20,000 people and registered another 20,000 to receive this kind of support. Healthcare in Kherson was strengthened through the provision of mobile services and provision of medicines and medical supplies enough to treat around 70,000 people for several months. The response also involved services that included counselling, transport, accommodation, the provision of repair materials, critical household items, and mineawareness campaigns Most recently, humanitarian actors travelled to affected settlements in the Kherson region to assess damages to homes and to support with emergency repairs in advance of the winter.

3. Source: Information note issued by Restoration of Ukraine on July 17, 2023

### *Long term consequences*

The destruction of the dam transcends immediate humanitarian concerns. It is poised to exert a substantial effect over a more extensive geographical area and population in the long run. The incident is foreseen to have severe, enduring consequences on Ukraine's environment, economy, and society, likely casting a gloomy and lasting pall over the country for many years. The long-term consequences include the possibility of irreversible loss of cultural and archeological heritage sites requiring urgent intervention and preservation.

## PDNA Objectives and Methodology

### *Objectives*

The key objective of the PDNA is to assist the Government of Ukraine to assess the impact of the Kakhovka dam destruction and define a recovery strategy, including estimating its cost. The specific objectives are as follows:

- Estimate the overall multi-sectoral impact of the disaster on the environment, economy, and society with a focus on all relevant affected regions and communities, i.e. Kherson, Mykolaiv, Dnipropetrovsk, and Zaporizhzhia regions. For specific sectors, other regions located upstream of the Dnipro River and Odesa region have been considered, if relevant.
- Support the government to develop a Recovery Strategy that outlines the short, medium, and long-term recovery and reconstruction needs.

### *Methodology*

The PDNA adopted the UN, EU, and WB methodology for the assessment of the impact of the disaster, consistently applying basic concepts of damage, loss, and post-disaster recovery and reconstruction needs across multiple sectors. Conducted through sector teams, the methodology also included a comparison of post-disaster conditions with pre-disaster baseline data to assess the disaster impact and determine the overall recovery strategy. It combined quantitative data with qualitative information to analyze and assess the environmental, social, and economic impacts of the disaster from the community level to the regional and national levels.

The assessment focused on the disaster-affected areas (Kherson, Mykolaiv, Dnipropetrovsk, and Zaporizhzhia Oblasts) and examined the damage to physical assets, indirect impact on economic activities, additional expenses caused by the breach, and the immediate rehabilitation/reconstruction needs as well as social and economic needs of the affected communities and sectors. It set uniform parameters for assessment within a sector, applied standard units for cost estimation, and included the cost of improved specifications and better resilience. Where possible, it also considered how the response to the situation improved the resilience of the affected population. The assessment is built on initial and detailed sector damage and loss assessments undertaken by the government and the data collected by other partners.

## *Key Assumptions for the Assessment*

By default, all sectors estimated Damage, Loss, and Needs. For some sectors where loss was minimal, loss estimation has been omitted. Sector-specific approaches to damage, loss, and needs estimation and key assumptions were validated in the sector meetings with GoU/KSE partners.

**Damage Estimation:** Damage was estimated for all infrastructure and assets for each sector at the Oblast level (Kherson, Mykolaiv, Dnipropetrovsk, and Zaporizhzhia) and categorized by public and private ownership. Damage was analyzed and applied to baseline assets, considering three levels aligned to RDNA2:

- fully destroyed (where structural damage or replacement cost of the asset was more than 40% of the original asset);
- major damage (where structural damage or replacement cost of the asset was under 40% of the original asset); and
- minor or no damage.

Sector teams considered the level of inundation and the type of asset to assign the level of damage. Damage was estimated from June 6th, 2023. The unit cost for estimation was drawn from RDNA2 and adjusted for inflation.

**Loss Estimation:** Loss was estimated for 18 months from June 6th. Unit cost for loss estimation was drawn from RDNA2 and adjusted for inflation.

**Needs Estimation:** Needs were estimated for immediate (2023-2024), medium-term (2025-2030), and long-term needs for ten years (2023-2033) (these timelines were adjusted for specific sectors where long-term impacts were more evident); to align with the RDNA timeline for needs. Care was taken that long-term needs already reflected in RDNA2 were not duplicated; only the additional needs due to the dam breach were reflected.

Estimates of damages, losses, and needs were presented in US dollars (USD). The official NBU fixed UAH/USD exchange rate of 36.5686, confirmed at the onset of the assessment, was applied.

The scope of the assessment included all communities and territories affected by the flood (specifically Kherson, Mykolaiv, Dnipropetrovsk, and Zaporizhzhia Oblasts), the loss of the dam, and the loss of the reservoir, and an aggregate level assessment. The assessment also sought to include the industrial production dependent on water supply from the hydropower plant located in Kherson, Zaporizhzhia, and Dnipropetrovsk, and outside the flood-affected area; and agriculture impacted by irrigation deficits in Kherson, Dnipropetrovsk, and Zaporizhzhia. Where possible, damage assessment considered the geology and soil characteristics of the area.

There were limitations in obtaining data within territories under the temporary military control of Russian Federation and within areas close to the front line. Examples included the left bank of the river, the Zaporizhzhia Nuclear Power Plant, and Crimea. The assessment team also acknowledges the unique nature of flood damage, which could raise recovery and reconstruction costs due to specialized equipment needs and procurement challenges. Moreover, comprehensive assessments were hindered by data limitations in sectors such as transportation, mine action, land, river, and marine transport.


# SUMMARY OF DAMAGE, LOSSES, AND NEEDS

**The PDNA estimates US$2.79 billion of direct damage to infrastructure and assets and over US$11 billion of losses, the lasting environmental impact being the biggest concern. The direct damage to infrastructure and assets was highest in the energy and housing sectors** (Figure 2). The energy sector suffered US$1.26 billion worth of damage (45% of the total), and housing damage amounted to over US$1.1 billion (39%). Culture (6%)[4], Municipal Services & Community Infrastructure (5%), and Water & Sanitation (2%) followed, recording significant damage.

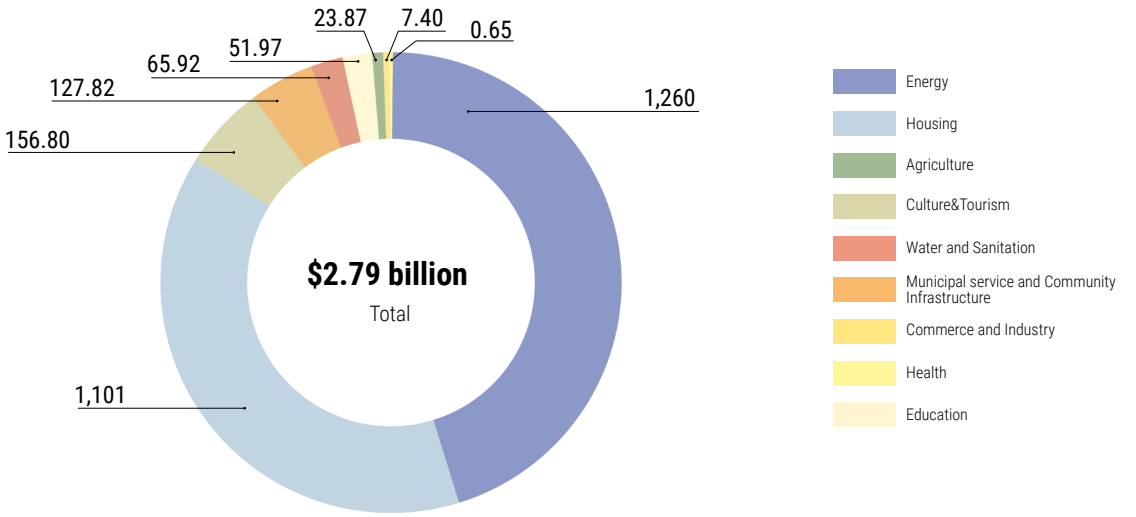



**Figure 2:** Damage by sector (US$ millions)

Some of the damage can be attributed to specific oblasts. Figure 3 Shows damage by oblast.

**Losses were highest in the environment and energy sectors (Figure 4), which are critical to long-term stability and recovery.** The environment sector recorded over US$6.4 billion (58%), and the energy sector accounted for US$3.8 billion (35%). Agriculture and fisheries (3%) also suffered major losses, followed by Culture (1%), Water & Sanitation (1%), Municipal Services & Community Infrastructure (1%), and Health (1%).

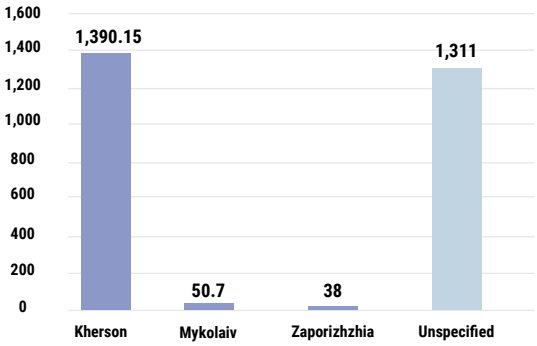



**Figure 3:** Damage by oblast (US$ millions)

4. Note: Estimated damage to cultural assets could increase in the future once on-field reconnaissance is made possible. Currently, only sites for which precise coordinates are available have been accounted for. There are also sites to which access is currently restricted due to security situation. As the water withdraws in the dam reservoir area, new, not yet registered, sites at risk may be revealed.

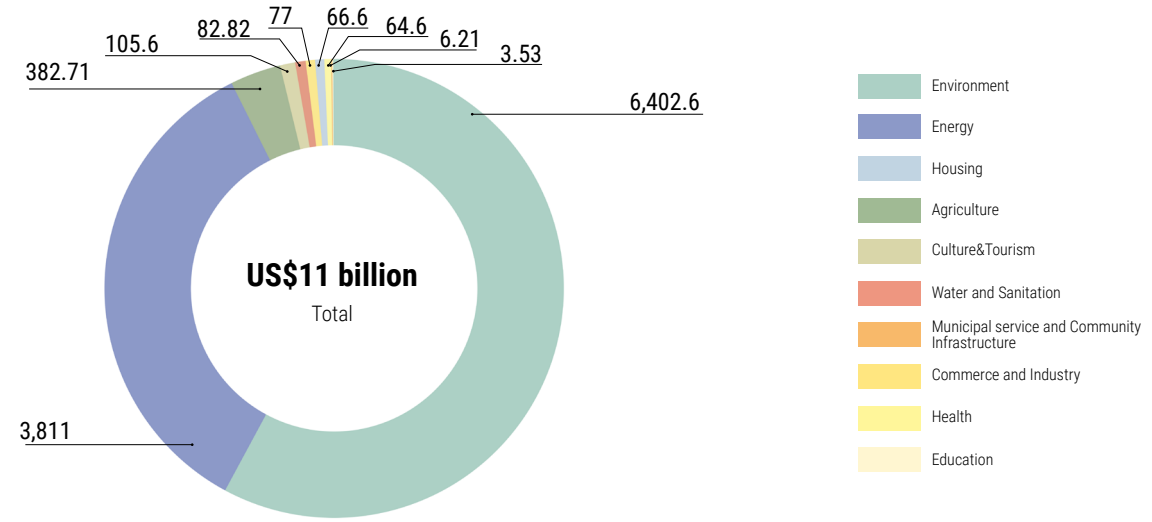
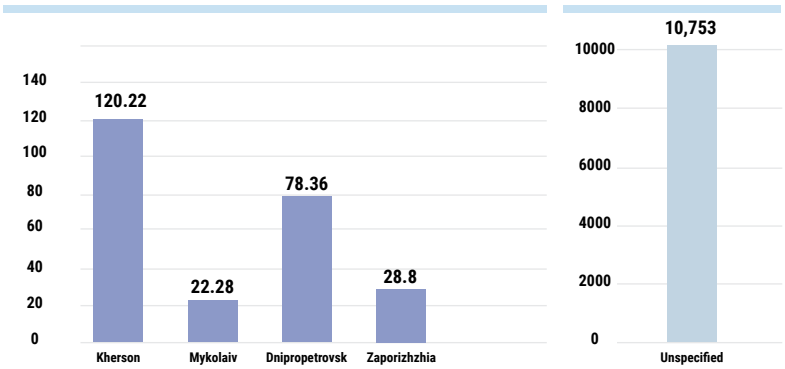



**Figure 4:** Loss by sector (US$ millions)

**Figure 5:** Loss by oblast (US$ millions)




Some of the loss can be attributed to specific oblasts. Figure 5 shows loss by oblast.

**Table 1:** Summary of damage and losses (US$ million)

| Sector | Damage | Loss | Total |
|---|---|---|---|
| **Social sectors** | | | |
| Health | 0.65 | 64.60 | 65.25 |
| Culture | 156.80 | 105.60 | 262.40 |
| Housing | 1,101.00 | 66.60 | 1,167.60 |
| Education | 51.97 | 3.53 | 55.50 |
| **Productive sectors** | | | |
| Agriculture | 23.87 | 382.71 | 406.58 |
| Commerce and Industry | 7.40 | 77.00 | 84.40 |
| **Infrastructure sectors** | | | |
| Municipal services and Community Infrastructure | 127.82 | 6.21 | 134.03 |
| Energy | 1,260 | 3,811.00 | 5,071 |
| Water and Sanitation | 65.92 | 82.82 | 148.74 |
| **Crosscutting sectors** | | | |
| Environment | | 6,402.60 | 6,402.60 |
| **Total for all sectors** | **2,795.43** | **11,002.67** | **13,798.10** |

**The PDNA estimates, on a Build Back Better basis, total recovery and reconstruction needs of US$5.04 billion, of which US$1.82 billion will be required in the immediate/ short-term (2023-24).** Total recovery needs are highest for the energy (35%) and housing (30%) sectors. Water & Sanitation (14%), Culture (7%), and Municipal Services & Community Infrastructure (6%) also require significant investment (Figure 6). In the immediate/ short-term, Housing, Energy, and Water & Sanitation require the highest investment (40%, 24%, and 19%, respectively).

**Figure 6:**
Total recovery needs by sector (US$ millions)

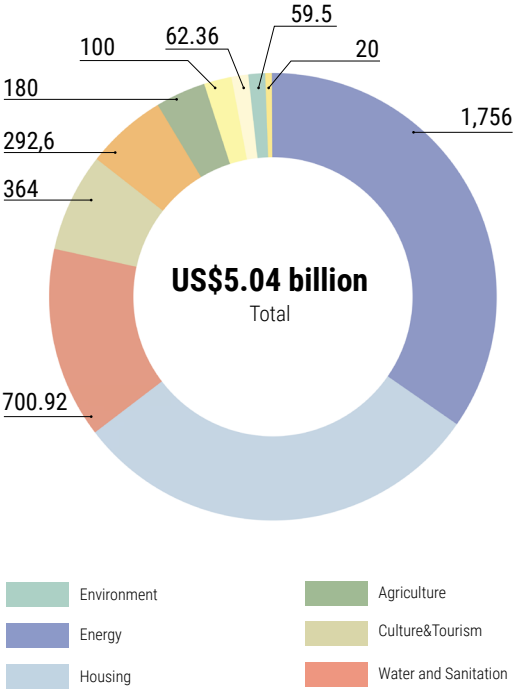
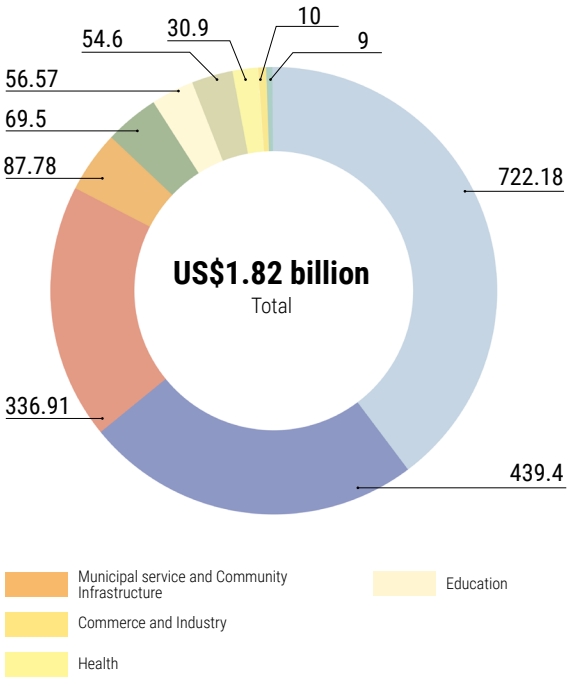



**Figure 7:**
Immediate/short-term recovery needs by time period 2023-2024 (US$ millions)




| Sector | Immediate/ short term - one year | Medium term - 5 years (2025-30) | Long term - 10 years (2023-33) | Total |
|---|---|---|---|---|
| **Social sectors** | | | | |
| Health | 30.90 | 69.10 | | 100.00 |
| Culture | 54.60 | 127.40 | 182.00 | 364.00 |
| Housing | 722.18 | 779.82 | | 1,502.00 |
| Education | 56.57 | 5.79 | | 62.36 |
| **Productive sectors** | | | | |
| Agriculture++ | 69.50 | 110.50 | | 180.00 |
| Commerce and Industry | 10.00 | 10.00 | | 20.00 |

**Table 2:**
Summary of recovery and reconstruction needs, including Build Back Better (million US Dollars)

| | | | | |
|---|---|---|---|---|
| **Infrastructure sectors** | | | | |
| Municipal Services & Community Infrastructure | 87.78 | 204.82 | 292.6 | 134.03 |
| Energy | 439.40 | 516.10 | 800.50 | 1,756.00 |
| Water and Sanitation | 336.91 | 364.01 | | 700.92 |
| **Crosscutting sectors** | | | | |
| Environment | 9.00 | 50.50 | | 59.50 |
| **Total for all sectors** | **1,816.84** | **2,238.04** | **982.50** | **5,037.38** |

# Summary of sectoral assessments

In later sections of this report, sectoral assessments are organized under Social Sectors, Productive Sectors, Infrastructure Sectors, and Crosscutting Sectors. **In this sub-section, we present summaries of sectors in the order of criticality, with high-impact, high-need sectors coming first.**

## *Environment*

**The Kakhovka hydroelectric dam breach caused a catastrophic flood, affecting 620 km² of land and altering river morphology, causing chemical pollution, habitat destruction, and potential long-term environmental impact.** As a result of Kakhovka dam breach, over 40 settlements were damaged in one of the most valuable agricultural regions in the world. Thousands of ecosystems were destroyed or appeared on the brink of destruction. Sediment transport led to a sediment plume in the Black Sea, causing high turbidity and affecting nearshore activities for months. Around 192 hazardous facilities were identified[5], with 54 as potential hotspots, releasing approximately 150 tons of machine oil alongside concerns of contamination from pesticides and fertilizers. Downstream surface water pollution was noted, with increased biological oxygen demand (BOD) and organic matter in the Black Sea, potentially affecting aquatic life and water quality. The disaster also impacted 330,000 ha of Protected Areas and 11,294 ha of Forested Areas. Tens of thousands of birds and wild animals were impacted or perished as a result of the flood. The Ministry of Environmental Protection and Natural Resources of Ukraine, following Government-approved methodology, has calculated the damages[6] to natural resources as approximately US$4.36 billion[7]. Due to the limited access to the flood-affected areas, validating the damages included in these calculations has been impossible. The PDNA estimates over US$6.4 billion in ecosystem service losses (58% of all losses) due to the impact on protected areas and forests.

**Reconstruction and recovery needs in the environment sector total US$59.5 million, with priorities including contaminated site assessments, cleanup, surveys, and de-mining.** Initially, the impacted area must be de-mined by trained personnel. Then the terrain must be cleared, affected biomass harvested, soils prepared, and robust, sustainable saplings planted. To accomplish this, roads and nurseries must be built, equipment procured, transportation arrangements made, and capacity-building programs implemented. In the long term, remnants of war equipment must also be removed. The entire flooded forest area must be reforested. The forestry sector needs US$37.5 Million. Addressing chemical and pollutant contamination necessitates a comprehensive site assessment, especially downstream of the dam, with initial costs projected at US$10 Million. To evaluate affected protected zones emphasizing red-listed species, inspections and field inventories are needed, with a funding need estimated at US$12 million.

5. The dam breach flooded fuel depositories and two animal carcass burial sites, and released wastewater into the Dnipro river.
6. The term "damage" as used by the GoU here maybe more in line with RDNA definition of "loss" than "damage".
7. 4 billion Euros

## Energy

**Preliminary estimates place the damage to the energy infrastructure in the Kherson oblast at US$1.26 billion, chiefly from the irreparable destruction of the Kakhovka Hydroelectric Power Plant (HPP), accounting for US$1.2 billion.** The flooding that followed damaged power distribution infrastructure worth US$44 million in Kherson Oblast, probably an underestimation due to limited data from the NGCA. Flooding also caused US$12 million in damages to 17 fuel stations and two oil depots. Damages to gas regulation points and district heating systems are estimated at US$4 million. **The energy sector's overall losses from the dam explosion surpassed US$3.8 billion.** The dam breach and drainage of the reservoir disrupted water supply to the cooling systems of the Zaporizhzhia Nuclear Power Plant (ZNPP), Ukraine's largest nuclear power plant, putting the operation of the ZNPP at risk. This implies major revenue losses for the state-owned power plant operator Energoatom, estimated at over US$3.6 billion. The Kakhovka HPP destruction caused revenue losses of US$96 million for its operator, Ukrhydroenergo, while the estimated revenue losses to the company due to unsold electricity and ancillary services amounted to US$138 million (annual average based). Debris removal and salvaging might cost another US$86 million.

**The energy sector's total reconstruction and recovery needs are estimated at nearly US$1.8 billion, with approximately US$439 million allocated for the immediate needs in 2023-2024.** These immediate needs aim to restore power, which is critical for reconstruction and recovery efforts. This includes the need to close liquidity gaps (US$373 million) in the power generation sector, particularly key state-owned electricity producers JSC Ukrhydroenergo and Energoatom. US$61 million is for repairs in the power sector, US$6 million is for reinstating the district heating infrastructure in the GCA, and US$25 million is for repairs to central heating units and boilers imn the NGCA. US$14 million is for a Dry Air-cooling system for the ZNPP to ensure safety until a stable cooling water supply is established.

## Housing

**The total damage to the housing sector is estimated at US$1.101 billion. Over 37,000 residential units were impacted by the flooding, with 15% damaged beyond repair.** This number includes apartment units and a dormitory, but over 97% are single-family houses, showing the impact on Ukraine's rural landscape, including peri-urban communities. The housing damage is spread across only two oblasts, with Kherson taking over 98% of the damage and Mykolaiv taking less than 2%. At the time of writing, only Mykolaiv and the right bank of Kherson oblast are accessible, while the left bank, with 73% of the damage, is inaccessible due to the war. **Losses in the housing sector are estimated at US$66 million, which reflects the cost of demolition and debris removal and the Government's one-time payment.** The loss estimation does not reflect bank losses and mortgage defaults, temporary rental and provision of shelter by owners, or adjusted rental income losses.

**The recovery and reconstruction needs for the housing sector amount to US$1.502 billion.** Addressing housing recovery needs requires an integrated green, resilient, and inclusive approach, focusing on returning families to their homes and restoring livelihoods and services. There is an urgent need to provide temporary rentals for displaced households, undertake winterization, repair partially damaged residential buildings, and establish a housing reconstruction and recovery strategy and implementation mechanism. The principal areas affected are low-lying and susceptible to future flooding, so reconstruction should enhance resilience of housing stock by improving land use planning, construction technology (for example by replacing clay foundations with cement ones to increase resilience to future flood events), and thermal performance of buildings.

## Water & Sanitation

**The Water & Sanitation (WSS) sector sustained physical damages estimated at US$65.92 million.** This includes damages worth US$39 million to WSS infrastructure and US$27 million worth of damage to machinery, equipment, and essential service components. **Losses have been estimated at US$82.82 million.** This includes decline in operational revenues, increase in operational costs, demolition and debris removal, cost of temporary water supply, cleaning, disinfection, quality testing, and prevention of water contamination and water-borne diseases.

**The WSS sector requires US$700.93 million as recovery and reconstruction costs[8] to address the needs of downstream flooded areas and upstream areas with water shortages.** The assessment is split between short-term (US$336.91 million) and medium- to long-term (US$364.01 million) expenditures.

## Municipal Services and Community Infrastructure

The total damage to the Municipal Services and Community Infrastructure sector is estimated at US$127.8 million. The damage is spread mainly across two regions, Kherson and Mykolaiv oblasts. The flooding impacted municipal assets, units, spaces, buildings, and facilities. Most of the affected areas and most of the damages in the Kherson region are on the left bank of the Dnipro River (NGCA). Losses in the sector are estimated at US$6.2 million, mainly from costs of debris removal and losses of revenue of waste management entities. According to IOM data, nearly a third of the pre-2022 population, primarily families and working-age individuals, left due to the war. The dam's destruction further displaced many. The remaining residents are mostly elderly, pre-retirement, or disabled, reliant on state services. Damage to administrative buildings hinders essential municipal services and discourages the return of young families.

The recovery and reconstruction needs for Municipal Services and Community Infrastructure are estimated at US$292.6 million, including US$87.8 million for immediate recovery. Addressing municipal sector recovery needs requires a strategic approach at the local level, restoring services using an integrated approach based on the Building Back Better principle (digital services, mobile centers for administrative services, etc.) that delivers resilient, sustainable, and efficient recovery solutions to affected communities. Damage to local community enterprise assets not only restricted services to the public but also impacted businesses subcontracted by local authorities for recreation and waste disposal services. Local budget revenues and service capabilities are strained as these businesses relocate or halt operations. Therefore, restoring services and rebuilding community infrastructure is crucial for recovery.

## Agriculture

**Total damage and loss to the agriculture sector[9] because of the Kakhovka dam burst is estimated at US$406.6 million.** Most of the damage and losses in the agricultural sector were attributed to crop production, at US$376.7 million (92%), primarily due to the disruption of irrigation. Damage and losses to fisheries and aquaculture comprised 8% of the total at US$31.5 million. Damage related to livestock production constituted the remaining US$0.24 million. These estimates, particularly damage, should be considered an underestimation due to a lack of data. Further, damage and losses in the NGCA remain unknown but are likely to exceed those in the GCA, given the flood extent and the significance of agriculture in the local economy.

The destruction of the Kakhovka dam worsened the situation of rural farming households whose income had already declined due to war-related disruptions in agriculture and increased production costs. Households in front-line areas displayed lower economic diversity

8. The Government of Ukraine's approach to restoration of water supply and sanitation services considers, when applicable, implementation of new infrastructural projects rather than reconstruction of existing damaged and outdated facilities. New projects are designed with increased capacities, modernized technologies, and decentralized service provision. Majority of existing and abandoned facilities are not considered as "damaged" and thus their cost is not included in damages and losses assessment.

9. The agriculture sector includes crops, livestock, fishery, and aquaculture. Irrigation is included in the crop production sub-sector. This report covers forestry under the Environment sector as forests in the affected area are non-productive.

and higher dependence on aid. The dam's destruction had multiple impacts – flooding obliterated crops, the reservoir drained out, depriving crops of irrigation for years, and fisheries were devastated. People employed in state-owned irrigation and aquaculture enterprises confront sudden unemployment. Declining household incomes, reduced harvests, damage to subsistence farming plots, and the cessation of local fisheries can cause fluctuations in local food prices and availability, threatening household dietary diversity and increasing food insecurity. In the wake of the dam destruction, over 306,500 hectares of cropland will transition to rainfed irrigation, decreasing yield by 70%, and lose the prospect of two harvests. In 2021, this irrigated land produced 2 million tons of grain and oilseeds. Production will now largely depend on unpredictable rainfall due to global climate change and potential micro-climate shifts from reservoir draining. The total loss of fishing in the reservoir, river, and delta will considerably affect the fishery sector, with the estuary and delta comprising 13.1% of Ukraine's 2021 fish catch.

**The estimated agriculture sector recovery needs amount to US$180 million over ten years, of which US$69.5 million is required in the immediate/ short-term.** To rejuvenate the agricultural sector, several measures are essential. Support must be provided to farmers with flooded land to maintain crops and livestock production and reduce reliance on surface irrigation by introducing new water sources and methods. Livestock farmers need alternative water solutions, and restoration of flood-damaged infrastructure is vital. Recovery of fish populations in affected areas requires particular attention, and farmers losing access to irrigation need help reconsidering cropping patterns, with incentives for using drought-resistant crops. Addressing liquidity issues by providing access to finance and innovative investment tools is crucial, along with a comprehensive monitoring program to ensure the health and markets of producers affected by contamination and infrastructure failure.

## *Commerce and Industry*

**The Kakhovka Dam breach resulted in damages of US$7.4 million to the Commerce and Industry[10] sector.** 65% of the damage affected industry, particularly small private firms, and the remainder impacted commerce in the flood-affected Kherson region downstream of the dam. Satellite imagery confirmed infrastructure damages, including flooded buildings and disrupted utilities.

**The total industrial and commercial losses due to the Kakhovka dam breach are estimated at US$77.0 million for 18 months.** The breakdown includes US$70.7 million for industry and US$6.3 million for commerce, reflecting decreased business activity in 2022, and considers both flooding and water deficit in the Kherson and Dnipropetrovsk regions.

The Kakhovka dam burst had a localized impact on commerce and industry, especially on the vital shipbuilding sector in Kherson and Mykolaiv. Existing challenges from the war were exacerbated. The preservation of this sector is crucial to the economy, education, and research. Metallurgy, another significant export-oriented industry, is concentrated in Dnipropetrovsk, Zaporizhzhia, and Donetsk regions; their importance has increased due to the destruction in the Donetsk region, and water and energy security are essential to prevent economic disruption.

**Total reconstruction and recovery needs for the commerce and industry sector are US$20.0 million.** This sum includes US$11.0 million for industry, US$9.0 million for commerce, US$13.0 million for physical facilities (65% of total needs), and US$7.0 million for service restoration, including demolition and debris removal.

10. The Commerce and Industry sector excludes ports and energy infrastructure, which are included in other parts of the Post Damage and Needs Assessment (PDNA), and it does not provide estimates for subsectors due to the lack of data.

## Health

**Flood damage to health infrastructure is estimated to be at least US$0.65 million**, including confirmed damage to two health facilities located under the control of the Government of Ukraine and excluding damage to nine facilities on the left bank of Dnipro River (NGCA). **The losses associated with urgent actions initiated by health sector stakeholders to restore continuity of services and mitigate potential health risks are estimated at US$64.6 million.**

Kakhovka Dam destruction further deteriorated the region's already fragile health situation, resulting in reduced access to health care, diminished ability to manage chronic diseases, interrupted continuity of care, worsening mental health, and growing financial barriers.

**The total needs for recovery of the health system are estimated at US$30.9 million for the initial 12 months of response and recovery and US$69.1 million for longer-term measures.** Immediate needs to restore continuity of services include enhanced public health surveillance to mitigate risks, additional workforce deployments, ensuring water quality in healthcare settings, and widespread risk communication and engagement campaigns.

## Culture

**The total damage to identified assets in the Culture sector is estimated at US$156.8 million.** This includes i) Sites and buildings, mainly archaeological sites with recognized cultural/social values (US$150.8 million), and ii) Tourism facilities (US$6 million). The most critical losses include revenue losses from tourism in Odesa Oblast, mud and debris removal expenses, and the protection of valued assets, estimated at US$105.6 million.

Living heritage, essential for community resilience, was already tremendously suffering from the war. Equally, the Cultural and Creative Industries (CCI) in regions affected by the dam breach were already struggling. The invasion and active battlefront had caused a significant decline in income for artists and cultural professionals, particularly in the Kherson and Mykolaiv regions, which had been occupied before being reclaimed by Ukraine. The dam breach exacerbated these issues, leading to a call for immediate attention and support to revitalize the CCI, assist professionals in rebuilding their livelihoods, and support communities in safeguarding Intangible Cultural Heritage (ICH).

**The total needs over the next ten years for recovery and reconstruction, including service delivery restoration, amounts to US$364 million, with short-term needs at US$ 54.6 million, medium-term needs at US$ 127.4 million, and long-term needs at US$ 182 million.** There is currently a need for assessment of the archeological sites which were exposed during the draining of the Kakhovka reservoir. After this assessment, the estimates of the damage to cultural heritage sites may potentially increase. During 2023-2024, physical recovery and reconstruction include valued assets protection, assessment and documentation, urgent rescue campaigns, and conservation and prevention of demolition of sites/buildings of cultural significance. For non-physical but essential measures, 15% of the value of long-term needs is allocated to 2023-2024 ($54.6 million).

## Education

**Explosion-induced flooding caused US$51.97 million in damages to 37 education institutions in Kherson and Mykolaiv oblasts**, with a 54%-46% split between GCA and NGCA. The damage cost distribution was 56.4% for secondary schools, 20.3% for preschools, and the remainder for two extra-curricular and two vocational training institutions. **Estimated losses of US$3.6 million** consist of 56.62% for student materials and devices, 23.78% on catch-up education, and 16.99% on teaching materials for teachers.

The impacts include severe mental and emotional harm, displacing students and educators, and leading many children to leave school. The disruption interrupts teachers' income, increases parents' and caregivers' expenses, and worsens educational inequalities.

**The reconstruction and recovery of damaged education institutions is projected at US$62.37 million (US$56.57 million short term, 5.8 million medium term)**, complying with the Ministry of Education and Science's vision, *emphasizing access to learning, engaged learners, and enabling education environment.* Secondary schools represent the largest cost segment at 48%.

# Key recommendations

Recovery from the Kakhovka Dam disaster is an integral part of the Government of Ukraine's strategy for recovery and reconstruction from the invasion by the Russian Federation. Therefore, the recovery framework will adopt the guiding principles for recovery and reconstruction outlined in the July 2022 Lugano Declaration for the Reconstruction of Ukraine as well as the set of complementary guiding principles proposed in RDNA 1 &2, which are based on international experience within post-conflict and post-disaster recovery and reconstruction efforts.

To kickstart recovery in the affected oblasts of Kherson, Mykolaiv, Zaporizhzhia, and Dnipropetrovsk, the top priority would be implementing the immediate recovery and reconstruction needs in all sectors. The return of a significant proportion of displaced residents would be necessary to give momentum to the reconstruction. To enable their return, short-term housing solutions are essential, along with restoration of water supply, sanitation, and other municipal services. The immediate and short-term needs of the agriculture, fisheries, commerce, and industry sectors must be met to revive the economy. Restoring the energy supply is foundational for all the above priorities. In the short term, one of the most important and challenging elements of recovery would be addressing the environmental impact of the dam disaster to the extent that it impacts the recovery process. The ecological devastation, of course, would take decades to remedy.

The sector-specific sections of this report articulate specific recommendations for the approach to recovery and reconstruction. A few excerpts are presented here. In the case of housing, it is proposed to develop a housing recovery strategy, including an operational manual with prioritization criteria for investments. Considering the limited public resources, this is essential for addressing the extensive needs in war-damaged areas and flood regions. From an environmental recovery standpoint, immediate actions recommended include employing pollution control equipment for observed contaminants, building physical barriers for soil erosion mitigation in key flooded areas, and prioritizing the design and implementation of detailed environmental assessments to clarify damages, losses, and planned recovery strategies. In the energy sector, it is proposed to fund the reconstruction of state-owned power companies Energoatom and JSC Ukrhydroenergo through policies that promote fiscal responsibility, external financing, and efficiency. It is also proposed to revitalize and transform the energy system, aligning with EU standards for a greener, more efficient landscape. A recommended financial investment of around US$700.93 million is proposed to restore the Water and Sanitation Sector (WSS) in four oblasts affected by the Kakhovka dam breach, as part of a broader US$7.15 billion national initiative for Ukraine's water infrastructure, with emphasis on reforms, institutional fortification, specialized assistance, and contingency planning for lasting functionality and revival of crucial services. An integrated approach to multi-sector recovery and reconstruction is articulated in the final chapter of this report.

# ECONOMIC AND SOCIAL IMPACTS

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# Macroeconomic impact

The macroeconomic impact assessment of the destruction of the dam reveals multifaceted consequences that have resonated across different sectors, namely agriculture and fisheries, commerce and industry, and municipal services and community infrastructure.

In the agriculture and fisheries sector, the absence of irrigation due to the destruction of the dam has led to a significant shift from irrigated to rainfed farming, resulting in a predicted 70% decrease in crop yield. Over 306,500 hectares will be affected, with a reliance now placed on unpredictable rainfall influenced by global climate change and potential micro-climate shifts from reservoir draining. The loss of fishing in the reservoir, river, and delta, comprising 13.1% of Ukraine's 2021 fish catch, will also significantly impact the fishery sector.

In commerce and industry, the Kakhovka dam burst's localized effects have primarily impacted shipbuilding and metallurgy, vital industries in Ukraine. The destruction has further strained an already vulnerable shipbuilding industry in cities like Kherson and Mykolaiv. Preservation and recovery of this sector are deemed critical due to its high added value and local expertise. While the metallurgy industry, mainly located in Dnipropetrovsk, Zaporizhzhia, and Donetsk regions, has managed the water shortage, concerns about the potential risk to the Dnipro dam underline the importance of ensuring water and energy security for these areas.

Damage to municipal services and community infrastructure has restricted services to the public and impacted businesses subcontracted by local authorities, straining local budget revenues and service capabilities. This has led to the relocation or halting of operations in areas such as recreation and waste disposal.

In conclusion, the dam destruction's effects have permeated various sectors, each facing its unique challenges. The agriculture sector must adapt to a drastic reduction in irrigation, the commerce and industry sector faces a potential restructuring with an emphasis on preservation and recovery, and municipal services are strained by the damage to local community assets. These challenges underline the complex interdependency of these sectors and highlight the necessity of a comprehensive approach to recovery that considers the diverse needs and potential risks within Ukraine's economic landscape.

# Human impact

The destruction of the Kakhovka Dam has brought a multitude of consequences across various sectors in the affected regions.

In terms of health, the dam's destruction has further deteriorated an already fragile health situation in the region, resulting in reduced access to health care and the ability to manage chronic diseases, along with interrupted continuity of care, worsening mental health, and growing financial barriers, at the same time increasing potential public health risks and putting additional burden on already weakened system to monitor and be ready to quickly respond to potential threats.

The situation for rural farming households in Ukraine, already grappling with the impacts of war, has worsened in the aftermath of the destruction of the dam. Flooding has obliterated crops, and the loss of the reservoir threatens long-term irrigation, affecting harvests for years. Fisheries have experienced total devastation, leading to a halt in their operations, sudden unemployment for those in state-owned enterprises, and heightened risks of food insecurity.

Nearly one-third of the pre-2022 population left the affected regions due to hostilities, and the dam's destruction further displaced many. Consequently, local governance has been hindered due to damage to administrative buildings, and the absence of essential municipal services discourages the return of young families. The remaining residents, primarily the elderly, pre-retirement, or disabled, rely more on state services but face accessibility challenges due to limited mobility and digital literacy.

Education has been significantly impacted as well, with damage to mental and emotional well-being and displacement of students and educators. Many children have left school, resulting in interrupted income for teachers, increased expenses for parents, and exacerbation of existing educational inequalities.

In the Cultural and Creative Industries (CCI), the dam breach has further strained regions already struggling due to the Russian Federation invasion. The invasion and active battlefront had already led to significant income declines for artists and cultural professionals,

particularly in regions like Kherson and Mykolaiv. The dam breach has exacerbated these issues, leading to a call for immediate attention and support. Living heritage was already tremendously suffering from the war. Its safeguarding is crucial, as it offers communities and individuals a sense of identity and continuity, and promote social cohesion, respect for cultural diversity and human creativity, while helping communities build resilient, peaceful and inclusive societies.

In conclusion, the destruction of the Kakhovka Dam has generated a cascade of challenges across multiple facets of life, including health, agriculture, municipal services, education, and culture. These areas were already strained due to existing conflicts and struggles, and the dam's destruction has magnified the challenges, creating an interconnected web of problems that compound each other. The situation calls for a comprehensive and integrated approach, addressing immediate needs while laying the groundwork for long-term recovery and resilience in these various sectors.

# SOCIAL SECTORS

# Health

## Summary

**Flood damage to health infrastructure is estimated to be at least US$650,000**, including confirmed damage to two health facilities located under the control of the Government of Ukraine and excluding estimated damage to nine health units on the left bank of Dnipro River, which is currently under the control of the Russian Federation. **The losses associated with urgent actions initiated by the stakeholders involved in the health sector to restore continuity of services and mitigate potential health risks are estimated at US$64.6 million.**

Kakhovka Dam destruction further deteriorated the region's already fragile health situation, resulting in reduced access to health care, diminished ability to manage chronic diseases, interrupted continuity of care, worsening mental health, and growing financial barriers, at the same time increasing potential public health risks and putting additional burden on already weakened system to monitor and be ready to quickly respond to potential threats.

**The total needs for recovery of the health system are estimated at US$30.9 million for the initial 12 months of response and recovery and US$69.1 million for longer-term measures.** Immediate needs to restore continuity of services include enhanced public health surveillance to mitigate risks, additional workforce deployments, ensuring water quality in healthcare settings, and widespread risk communication and engagement campaign.

## Context

Since the Russian Federation's full-scale invasion of Ukraine on February 24, 2022, war has considerably impacted the health system and the population's overall health. As of 17 July 2023, WHO recorded 1,067 attacks on healthcare, which impacted health facilities, transport, warehouses, personnel, and patients. According to the Ministry of Health of Ukraine, due to the ongoing war 1406 healthcare facilities are partially and 186 are completely destroyed. This undermined the ability of the health system to provide essential health services, leading to deterioration in the level of access to healthcare services and medicines in the country, particularly for people living in regions close to the front line and areas that are not partially or fully controlled by the Government of Ukraine, and for people who have been internally displaced. While the WHO health needs assessment demonstrated that as of December 2022[11], almost 50% of people seeking care faced at least one barrier, at the same time, the country's health system remained resilient and overall access to some level of health services was still high, with a tendency to be slowly restoring since the onset of the war. **However, the situation was distinctively different in the areas experiencing or which have experienced hostilities, such as those Southern regions most impacted by the Kakhovka dam destruction.**

WHO HeRAMS assessment[12] demonstrated that while some 96% of the public healthcare facilities were fully functioning nationwide during November 2022-May 2023, there were already much more severe health service disruptions in Kherson oblast, where only 43% of healthcare facilities were functioning, 71% sustained partial or total damage to their building, and 58% of health facilities sustained partial or total damage to their equipment (see Figure 1). Access to maternal and newborn care, mental health services, sexual and reproductive health services, and non-communicable diseases services was already constrained in the region, mainly due to a lack of qualified health personnel and medical supplies and equipment. In June 2023, according to the results of crowd-sourced data collection in frontline oblasts[13], only 48% of Kherson region residents reported having access to family doctor (12% had no access at all and 40% did not know), while residents of nearby regions under the control of the GoU reported much better access to family doctors - 75% in Mykolaiv, 87% in Odesa and 83% in Zaporizhzhia, for example.

11. Health needs assessment of the adult population in Ukraine: survey report: December 2022 (who.int)
12. HeRAMS Ukraine Baseline Report 2023: Operational status of the health system, November 2022 - May 2023 (who.int)
13. Frontline oblasts needs assessment, internal WHO Country office in Ukraine assessment, not published

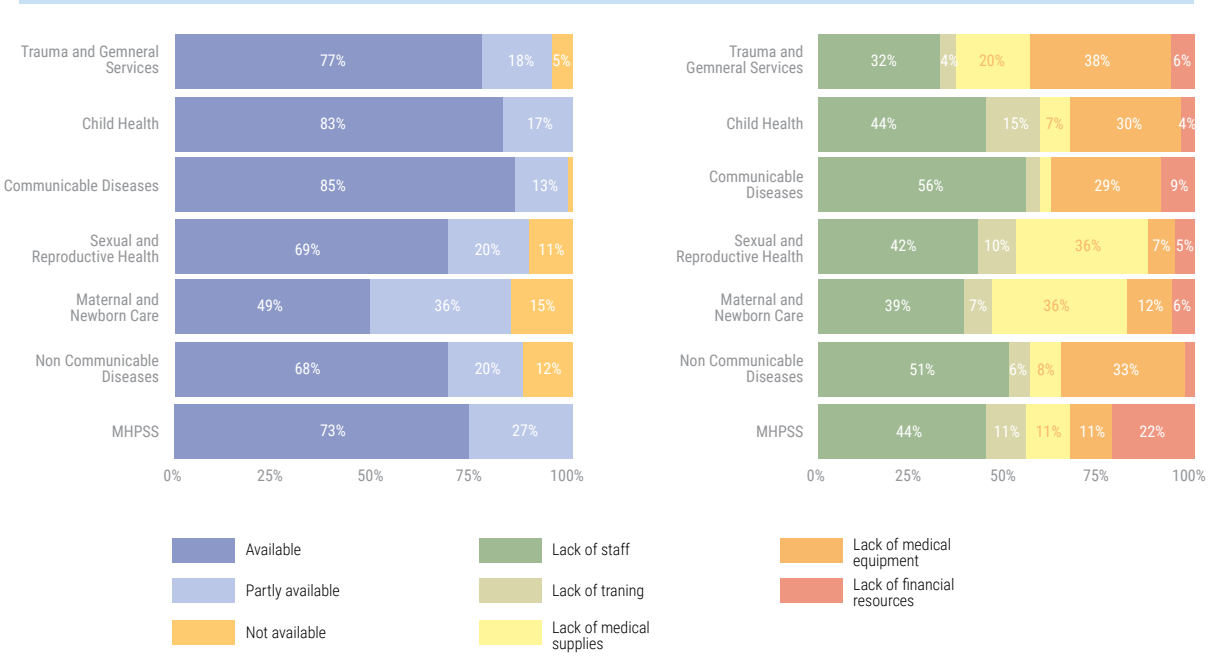



**Figure 8:** Health service availability in Kherson Oblast before the Kakhovka Dam destruction

Source: WHO HeRAMS assessment

The destruction of the Kakhovka dam only further exacerbated these problems while increasing population health needs. At the same time, part of the Kherson oblast, which reportedly has been the most affected by the flooding, is under temporary Russian military control and inaccessible neither to the Government of Ukraine nor to UN personnel, which makes it impossible to assess or verify the level of damage and estimate both immediate and long-term needs.

## *Damage and Loss Assessment*

### Damage to health infrastructure and equipment

**Interim flood damage to health infrastructure is estimated at US$650 000 (Table 3), with further estimations necessary for territories under temporary Russian military control.** This doesn't include the damage and losses sustained from military action, which was ongoing even during the emergency response to the dam destruction. Comprehensive assessment of flood damage to health infrastructure and equipment is impossible at the time of writing the report, given that the areas that are most affected by the flooding are not under the control of the Government of Ukraine and the UN didn't receive access to territories that are under temporary occupation by the Russian Federation military.

At the time of assessment, only two health facilities located under the control of the Government of Ukraine have been officially confirmed damaged by the flooding (one outpatient clinic building fully damaged and equipment damaged in a TB hospital), located in the Kherson region. However, there is estimated to be considerable damage to health facilities and equipment on the left bank of the Dnipro River, which is currently under the control of the Russian Federation: the satellite images and modeling estimate that as many as nine buildings of health facilities totaling up to 4,900 $m^2$ [14]could be affected in the left bank which will be possible to assess the damage, losses and needs only after the area is back under the control of the Government of Ukraine.

14. This publication was produced using data provided by EMITTER project, which is realized under the financial support of the European Union. Its contents are the sole responsibility of the project and do not necessarily reflect the views of the European Union.

Table 3: Damage* by asset type (US$) as of July 10, 2023

Source: National health authorities

*does not include estimates on potential damage to health infrastructure and equipment in the territories under Russian control or damage sustained by military action

| Facility type (confirmed damage) | Total value (US$) | Share of total (%) |
|---|---|---|
| General outpatient clinic (fully damaged) | **550,000** | 85 |
| Specialized equipment TB clinic | 100,000 | 15 |
| **Total** | **650,000** | **100** |

## Damage to health infrastructure and equipment

**The losses associated with urgent actions initiated by the stakeholders involved in the health sector to restore continuity of services and mitigate potential health risks are estimated at US$64.6 million.** These include the Ministry of Health and its partners' interventions initiated or which should be initiated as soon as possible to ensure additional health workforce deployments for the region, additional stocks of clean water for health facilities, hygiene items for the patients and staff of the health facilities, and the need to undertake additional water purification measures needs for increased public health surveillance and higher workload of laboratories. It is estimated that these additional interventions to mitigate the environmental risks and address increased needs will be in place for the 18 months (about one and a half years) following the dam disaster.

**The key initial measures initiated by the Government of Ukraine to ensure continuity of health services and mitigation of public health risks:**

Table 4: Losses to the health sector (US$ million) as of July 10, 2023

Source: Assessment team

| Category | Component | Total |
|---|---|---|
| Actions to Restore Service Delivery and Mitigate Public Health Risks | Public health surveillance | 7.8 |
| | Water quality assurance & basic hygiene items for health facilities | 40.2 |
| | Health workforce deployments | 6.5 |
| | Laboratory services | 4.5 |
| | RCCE | 0.6 |
| | Additional treatment and vaccines | 3.3 |
| | Points of entry control | 1.6 |
| | One Health interventions | 0.1 |
| **Total** | | **64.6** |

## Human Impact

According to the national authorities[15], as of July 10, 2023, there were in total 58 confirmed people affected, including 29 fatalities (27 in Kherson (including an SES employee) and 2 - in Mykolaiv region) and 28 injuries (including five police officers and ten rescuers of the SES, injured during the evacuation of civilians and disaster relief operations). One person died during the evacuation efforts. Additionally, the whereabouts of 41 people were unknown at the time of preparing this report which could later add to the human cost of the disaster as the debris is cleared, but more importantly, as more territories return to the control of the Government of Ukraine and the flood impact becomes more apparent.

The destruction of the Kakhovka dam has interrupted access and continuity of health services, for communicable and non-communicable diseases, for the population, both due to the outflow of the health workforce and damage to social infrastructure (roads, buildings, and equipment), as well as fear of population to seek care in the area that has seen constant shelling since returning to the control of the Government of Ukraine, even during the evacuation efforts[16]. Disrupted supply routes for medicines and affected stocks on the ground are a major concern for the population's access to treatment of chronic conditions, with 14% of the local population reporting a lack of access to medicines and 23% of them reporting not having access by the reason related to flooding. Only 59% received information or guidance regarding health and hygiene practices after the flood, and 72% knew how to prevent waterborne diseases[17].

The flooding has increased the risk of future injuries and death due to landmine shifting and displacement of other explosives and unexploded devices. This puts the territories under the increased potential need for scaling up emergency, injury, and trauma care, as well as increasing the awareness efforts among the local population regarding the dangers of explosives.

## Reconstruction and Recovery Needs, including Build Back Better

**The health system's total needs for immediate recovery are estimated at US$30.9 million for the initial 12 months of response and recovery and US$69.1 million for longer-term measures (Table 2).** These estimates aren't comprehensive regarding infrastructure (structures and equipment) rebuilding needs in the region, as the flood damage only added to existing damage to health facilities sustained over 1.5 years of war and intense shelling. The total need for rebuilding and reconstruction of health facilities in the areas affected by flooding must be estimated in the scope of overall national and regional post-war recovery planning, newer and leaner health facility network planning, and considering subsequent war damage.

Additionally, needs estimates aren't available for the areas that are currently under the temporary military control of the Russian Federation due to lack of access. Additional re-assessment of the public health situation along with an updated security landscape is required after initial 6-12 months of response to plan future actions for the affected region in the scope of the national post-war recovery planning. This can be done separately or in the scope of the rapid damage and needs assessment planned for February 2024. The TB laboratory equipment that was reportedly damaged by the fighting and/or flood is planned to be procured by the international development partners and it therefore is not included in the needs calculations.

**Immediate needs to restore continuity of services include needs for enhanced public health surveillance to be able to mitigate risks, additional workforce deployments, ensuring water quality in healthcare settings, and widespread risk communication and engagement campaign. Immediate needs for increased surveillance are estimated at US$5.2 million over the next 12 months, with further re-assessment necessary according to the ground situation.** The destruction of the Kakhovka dam and subsequent flooding has further deteriorated an already fragile health system and precarious public health situation in the region, increasing public health threats. Therefore, there's an immediate need for the deployment of additional staff of trained epidemiologists to support surveillance and contact tracing, as well as the deployment of public health rapid response teams to support outbreak investigation. These should be followed by capacity building on priority diseases for all public epidemiologists in the affected regions.

15. Restoration digest by the Ministry of Recovery (ex communities and territorial development)
16. Ukraine war: Kyiv accuses Russia of shelling Kherson evacuations - BBC News
17. Flood assessment, internal WHO Country office in Ukraine assessment, not published

**The need for water quality assurance in healthcare settings is estimated at US$14.6 million, while the need for an additional health workforce to compensate for the lack thereof due to displacement is estimated at US$4.3 million.** There was a pre-existing problem with a lack of health personnel - for example, almost two-thirds (69%) of facilities in Kherson Oblast couldn't provide skilled care during childbirth primarily due to the lack of trained personnel [18], which was only exacerbated by population movement away from flooded regions. Thus, to restore the delivery of essential health services, emergency medical teams, mobile teams, and temporary deployment of selected specialties are required for the next six months. Additionally, there's an urgent need to intensify risk communication in the region to raise awareness and educate the population who remained about public health threats, mine shifting threats, and actions to seek care for priority conditions, etc.

**The principal initial and longer-term recovery and reconstruction needs include these measures:**

18. WHO HeRAMS assessment

Table 5: Recovery and reconstruction needs (US$ million) as of July 10, 2023

| Category | Component | Immediate/ short term Up to 1 year | Medium- to long-term Over period of 5 years | Total |
|---|---|---|---|---|
| **Reconstruction Needs** | Investments to rebuild a health facility affected directly by flooding | | 0.5 | 0.5 |
| **Service Delivery Restoration Needs** | Public health surveillance | 5.2 | 18.3 | 23.5 |
| | Water quality assurance | 14.6 | 30.8 | 45.4 |
| | Health workforce deployments | 4.3 | 0.0 | 4.3 |
| | Laboratory services | 3.0 | 15.0 | 18.0 |
| | RCCE | 0.4 | 0.8 | 1.2 |
| | Additional supplies (treatment and vaccines) | 2.2 | 3.3 | 5.5 |
| | Enhanced points of entry control | 1.1 | 0.0 | 1.1 |
| | One Health | 0.1 | 0.4 | 0.5 |
| **Total** | | **30.9** | **69.1** | **100.0** |

## *Key Recommendations to ensure essential health service delivery and sound public health situation in the affected regions.*

Despite the war and ongoing attacks on healthcare, the health system demonstrated remarkable resilience in the face of immense challenges. However, the health service provision has been compromised in Kherson due to proximity to the frontline and worsened following the Kakhovka Dam destruction. While responding to the increased population health needs and public health threats in the region, it's important to recognize the interconnection of the health system nationally and ensure coherent recovery planning for the effected

regions in line with draft National Health Strategy 2030 and post-war recovery planning. This means considering the following recommendations:

- Assess the need and plan for future health infrastructure investments in the region according to updated service delivery models and ongoing hospital network planning processes;
- Ensure sustainability of the response actions – such as mobile teams deployment, supplies deliveries, and additional vaccines administration - into the design of the ongoing health reform and service delivery models;
- Implement the "building back better" approach to the dam response disaster when scaling up the capacity of public health surveillance teams and laboratory capacities; ensure integration with the national public health network and sound reporting to Ukrainian Public Health Center;
- Adopt and implement the "One Health" approach by fostering interconnectedness and ensuring effective cross-sectoral collaboration and coordination across multiple sectors, including public health, animal health, agriculture, environment, and other relevant domains that have been affected by the flooding;

### *Notes on the Methodology, including Assumptions and Limitations*

The information used in this assessment was obtained from various sources: national authorities, local health authorities, requests submitted from health facilities, and previous international agencies' experience responding to similar situations. Current calculations do not include actions related to a potential cholera outbreak since there has not been a confirmed case at the time of writing.

## Culture

### *Summary*

**The total damage to identified assets in the Culture sector is estimated at US$156.8 million.** This includes i) Sites and buildings, mainly archaeological sites with recognized cultural/social values (US$150.8 million), and ii) Tourism facilities (US$6 million). The most critical losses include revenue losses from tourism in Odesa Oblast, mud and debris removal expenses, and the protection of valued assets, estimated at US$105.6 million.

Living heritage, essential for community resilience, was already tremendously suffering from the war. Equally, the Cultural and Creative Industries (CCI) in regions affected by the dam breach were already struggling. The invasion and active battlefront had caused a significant decline in income for artists and cultural professionals, particularly in the Kherson and Mykolaiv regions, which had been occupied before being reclaimed by Ukraine. The dam breach exacerbated these issues, leading to a call for immediate attention and support to revitalize the CCI and assist professionals in rebuilding their livelihoods, and support communities in safeguarding Intangible Cultural Heritage (ICH).

**The total needs over the next ten years for recovery and reconstruction, including service delivery restoration, amounts to US$364 million, with short-term needs at US$54.6 million, medium-term needs at US$127.4 million, and long-term needs at US$182 million.** During 2023-2024, physical recovery and reconstruction include valued assets protection, assessment and documentation, rescue campaigns, and conservation and prevention of demolition of sites/buildings of cultural significance. For non-physical but essential measures, 15% of the value of long-term needs is allocated to 2023-2024 ($54.6 million).

## Context

The area impacted by the dam destruction has a unique high-density concentration of cultural assets, several of which are of national importance. The banks of the Lower Dnipro with adjacent estuaries are extremely rich in archaeological sites, many little investigated. A brief analysis of the right bank's known archaeological locations shows more than 150 sites and graveyards, including underwater sites. Field research surveys were conducted in 1940-1960, before the dam's construction; for these sites, then flooded, documentation nowadays is little, and their location is not georeferenced, preventing locating them through satellite imagery analysis. Several sites are not yet legally protected, neither as of national nor local importance.

## Damage and Loss Assessment – Dam destruction Effects and impact

**As of July 8, 2023, the total damage cost from identified assets is estimated at US$156.8 million concerning: i) Sites and buildings imbued with recognized cultural/social values (US$150.8 million), among which archaeological sites represent a high part; and ii) Tourism facilities (US$6 million).** Further details by oblast are provided in the table below. Kherson is the most impacted oblast, taking over 72 percent of the estimated damage in all the oblasts.

As for losses, they were calculated by adding revenue losses from oblasts indirectly impacted by the dam explosion (mainly Odesa Oblast) and the costs of emergency interventions and debris removal. **The most critical losses include revenue losses from tourism in Odesa Oblast, mud and debris removal expenses, and the protection of valued assets for the impacted oblasts, estimated at US$105.6 million.**

**Table 6:** Damage as of July 8, 2023, and losses by Oblast (US$ million)

Source: Assessment team.

| Oblast | Damage | Damage share of total (%) | Loss | Loss share of total (%) |
|---|---|---|---|---|
| Dnipropetrovsk | | 0.0% | | 0.0 |
| Zaporizhzhia | 38.0 | 24.3% | 20.8 | 19.7 |
| Mykolaiv | 5.7 | 3.6% | 4.1 | 3.9 |
| Kherson | 113.8 | 72.1% | 77.1 | 73.0 |
| Odesa | | 0.0% | 3.6 | 3.4 |
| **Total** | **156.8** | **100%** | **105.6** | **100.0** |

### Disaster Effects

Damage is particularly evident downstream of the dam, where the depth of the floodwater, averaging over 3 meters in the first days, significantly affected cultural heritage sites, built heritage, cultural institutions, museums and collections, and religious and worship places, considering the specific observation of their geo-localization about the flood evolution and the progressive decreasing of its mechanical stress (wave action, subsurface water movement) over several days. Some of these sites were still flooded as of 8 July 2023. For assets subjected to extended periods of flooding, there is a high likelihood that their structural integrity becomes compromised, leading to a variety of damage (erosion of foundations, instability and weakening of walls' structural behaviors, as well as compromised load-bearing structures, making them susceptible to collapse due to rapid saturation). Observations have already revealed incidents of structural cracks and sinking, raising concerns for potential future occurrences.

The left-bank region of Kherson, currently inaccessible, has been the hardest hit due to its lower geographical

location than the right bank. This situation poses a dual risk to the cultural heritage present in the area. The force of the flood has accelerated the erosion along the coast and riverbanks, significantly impacting the decay process of cultural structures. Furthermore, in addition to the flooding, the region remains exposed to the direct impact of artillery shelling, exacerbating the risks this valuable immovable and moveable heritage faces. Nationally protected cultural heritage, such as the former residence of the native art artist Polina Rayko in the flooded town of Oleshky, is particularly recognized as being critically affected. The status of the collections is difficult to account for, as a large part of it was already relocated to safer areas due to the full-scale invasion. However, movable heritage, including books and archival collections, faces severe deterioration risks and is vulnerable to looting and illicit trafficking. This complex situation requires urgent attention and preservation efforts to safeguard these invaluable cultural assets.

Artifacts have been reported to be washed down due to the floodwaters, some reaching beyond the Dnipro estuary, Odesa [19]. The negative effects of damp objects and collections (hygrometric variation and prolonged exposure to direct sunlight) are feared, such as the loss of surface, deformation, and cracks, especially in organic materials. Books, manuscripts, and diverse supports of inventories and archival records are particularly at risk, as wet archive material would usually develop fungal growth within 48 hours if it is not properly dried or frozen (as specific case-by-case occurrence would require).

Although exact damage cannot yet be quantified, the voiding of the reservoir is also significantly impacting cultural heritage. The receding water level of the Dnieper River, leaving isolated ponds in the area formerly covered by the reservoir, is unveiling archaeological structural remains, several findings, and two ancient shipwrecks. The integrity of this heritage and archaeological deposits faces profound compromise under the current circumstances, with previously buried remains now exposed to the impact of strong pressure of receding water and abrupt changes in environmental conditions and moisture levels, rendering them increasingly vulnerable. This process can result in the loss of surface layers and structural damage, including the development of capillary cracks, among other detrimental effects. The serious risk of illicit excavations and looting is particularly concerning, as it poses a significant threat to the uncovered archaeological structures and findings. Both downstream and upstream, damaged and/or exposed artifacts must be rescued and moved to temporary safer deposits and treatment-equipped spaces.

### 4.2.3.1 Disaster Effects

Although exact figures are not yet available, generally speaking, the sector of Culture, across all its subsectors, is already suffering, due to the war, from a drastic depletion of specialized professionals and skilled workers, and cultural institutions operating in the dam destruction areas are understaffed, or not anymore operational in particular in the left bank of Dnipro River. This will require proper measures to restore the full-fledged work of the institutions to perform urgent documentation, rescue, conservation, and safeguarding measures. The development of conditions for the resumption of activities of cultural institutions is paramount.

Before the dam's breach, the Cultural and Creative Industries (CCI) in the affected regions were already facing significant challenges due to the full-scale invasion by the Russian Federation and the active battlefront in the four oblasts. As a result, artists and culture professionals experienced a considerable decline in market opportunities, leading to a notable reduction in income. Furthermore, the oblasts that were hit the hardest, such as Kherson and Mykolaiv, had already been subject to partial or complete occupation before these territories were regained by Ukraine. Consequently, CCI were practically nonexistent in these regions when the dam breach occurred. The combination of pre-existing difficulties caused by the invasion and occupation, alongside the subsequent disaster, has placed immense strain on CCI in these areas. Immediate attention and support are crucial to help revitalize the CCI and assist artists and professionals in rebuilding their livelihoods in the aftermath of these challenges. Although tourism in the country is still unlikely, especially for international tourists, some investments ahead of the summer were afforded, for instance, in Odesa beach resorts, to protect the seawater perimeter from floating mines.

The flood has further deeply affected the safeguarding of ICH, undermining the social fabric, daily practices, and livelihood of living heritage practitioners, producers, community members, cultural professionals, and artists. Among the 74 ICH elements listed on the National Registry of Intangible Cultural Heritage of Ukraine, four are specifically located in Kherson, and 2 in Dnipropetrovsk oblasts, the viability of which might be further at risk and require urgent safeguarding measures [20].

20. For instance, reportedly, a Byzantine amphora was found on an Odesa beach and deposited (12 June) at the Kherson local history museum (https://english.nv.ua/life/man-finds-ancient-byzantine-amphora-on-odesa-beach-after-kakhova-dam-flood-ukraine-news-50331636.html).

20. https://ich.mkip.gov.ua/. The Cossack songs of Dnipropetrovsk Oblast is inscribed on the UNESCO List of ICH in Urgent Need for Safeguarding (2016), https://ich.unesco.org/en/state/ukraine-UA?info=elements-on-the-lists.

## *Reconstruction and Recovery Needs, including Build Back Better*

**The total needs over the next ten years for recovery, reconstruction including service delivery restoration, amounts to US$364 million, with short-term needs (2023-2024) at US$54.6 million, medium-term needs (2025-2030) at US$127.4 million and long-term needs (2023-2033) at US$182 million.**

**During 2023-2024, physical recovery and reconstruction include valued assets protection, assessment and documentation, rescue campaigns, and conservation and prevention of demolition of sites/buildings of cultural significance.** For non-physical but essential measures, 15% of the value of the needs is allocated to 2023-2024 needs ($54.6 million). This early stage (2023-2024) would expect:

- GIS satellite-imagery-based monitoring, including identification of cultural sites and assets and assessment of damaged cultural heritage;
- on-site damage assessment, emergency inventorying, and documentation; emergency rescue campaigns for exposed archaeological remains, and scattered emerging artifacts, including recovery and preliminary conservation of moveable heritage; improvement of archaeological site burial conditions advised by topographical survey and subsurface prospection (geophysics); removal of cultural objects and assets (as necessary);
- drying of moveable cultural assets, organizing/equipping air-dry suitable sites at a safe distance from flooded assets; packing and stabilizing the conditions, including freezing when required, of wet paper material, archives, and books to avoid secondary damage of wet material;
- drying of flooded structures to prevent distortion and rotting of wooden elements, cracks in the plaster, mold growth, staining, and salt migration, among others;
- cleaning of cultural heritage structures, collections, artifacts, and fragments. Removal of hazardous waste is costed within the demining chapter. According to flood water classification, when the risk of biological contamination is rated high, as it may contain chemicals and/or sewage, decontamination will be required for damaged cultural assets and artifacts;
- surface treatment immediately following excavation to prevent the unnecessary formation of insoluble deposits on surfaces; first aid, consolidation, and conservation of sites and finds during rescue excavations, as well as the conservation of finds already emerged; stabilization and conservation measures for cultural assets;
- setting-up temporary storages for salvaged artifacts and relocation of collections in safe and secure places and immediate conservation to prevent further loss and looting;
- boosting the fight against looting and illicit trafficking of cultural properties (analysis, training, networks, etc.).

Moreover, in the immediate term, service delivery restoration includes thoroughly reconsidering the territorial and urban Master Planning for the regions affected by the dam breach. Additionally, dedicated support to restore the CCI and safeguard ICH will be needed. Efforts will be focused on revitalizing the CCIs to stimulate economic growth and empower local artists and professionals. Simultaneously, safeguarding and promoting cultural practices and traditions will be a priority in order to ensure cultural continuity and well-being of the affected communities, despite the challenging circumstances. These coordinated endeavors aim to facilitate a progressive and inclusive recovery process, nurturing the impacted regions' physical landscape and rich cultural fabric, thereby securing a resilient and vibrant future.

Table 7: Recovery and reconstruction needs (US$ million) as of July 8, 2023

| Category | Component | Short term (2023-2024) | Medium term (2025-2030) | Long term (2023 2033) | Total |
|---|---|---|---|---|---|
| **Reconstruction Needs)** | Damage assessment, emergency documentation & rescue campaigns for dispersed archaeological artefacts and structural remains (backfilling, rescue excavation, etc.) | 4.2 | 9.8 | 14.0 | 28.0 |
| | Emergency measures for cultural immoveable (shoring, propping, structural reinforcements, sheltering and protection measures, including mud & debris removal, cleaning) and moveable properties (inventories, etc.) and necessary interventions and conservation works for sites that were revealed from under the water | 18.9 | 44.1 | - | 63.0 |
| | Repair assets as feasible to restore function, preservation and restoration of built heritage, historic cities and cultural infrastructures to prevent/mitigate demolition of sites/buildings of cultural significance | 12.6 | 29.4 | - | 42.0 |
| | Reconstruction/Restoration of assets | 6.3 | 14.7 | 126.0 | 147.0 |
| **Service Delivery Restoration Needs** | Reconsider the Master Planning of the areas affected by the dam explosion, to plan the interventions based on how each area will be affected in the future after the reconstruction of the dam | 100% | 105.6 | 100.0 | |
| | Reinforce capacities of professionals | 44.1 | - | 63.0 | |
| | Support restoring the creative industry and the safeguarding of Intangible Cultural Heritage through a community-based approach | 12.6 | 29.4 | - | 42.0 |
| | Operational cost | 6.3 | 14.7 | 126.0 | 147.0 |
| **Total** | | **54.6** | **127.4** | **182.0** | **364.0** |

## Key Recommendations to revitalize and restore the Culture sector

In the short-to-medium-term, the primary focus will be on the comprehensive documentation of cultural assets, encompassing historic cities, built heritage, museums, monuments, national/regional theaters, religious sites, and more. This documentation process aims to understand better the specific needs and requirements for planning effective conservation and recovery. Considering the challenges posed by the extent of damage, it is crucial to acknowledge that immediate repair and rehabilitation of the affected buildings may not be feasible in many cases. Therefore, approximately 35% of the restoration efforts will be carried out in the short to medium term, with the remaining 65% planned for the long term. In addition to the physical preservation of cultural assets, both short-to-medium and long terms include reconsidering the master planning of the affected areas, as well as safeguarding ICH by enabling communities to identify, through the identification of a community-based need, how their living heritage has been affected by the dam destruction and what measures are needed to maintain its practice and transmission. Supporting the continued practice of living heritage and CCIs is also an integral part of the approach. Operational costs associated with these interventions are reflected in Table 7 including short-, medium- and long-term needs.

**The identified measures are articulated in an area-based approach and may be subject to a staggered diachronic approach, as cultural properties and sites have different accessibility**, with the Dnipro River marking the front line of active conflict between Russian and Ukrainian armies. **Since the very early stage, it is highly recommended to intervene in increasing the legal protection of cultural heritage, listing relevant heritage assets as national relevance, and ensuring that they are integrated into the territory and city masterplans,** including plans for repairing or relocating/constructing a new dam on a different location. As there are operational limitations within territories under the temporary military control of the Russian Federation and within areas located close to the front line, all interventions on the ground will require a **high level of coordination with various national and regional administration authorities, humanitarian, military and law enforcement entities, as well as local entities and communities** since conception and operationalization of on-site rapid assessment, emergency documentation, rescue campaigns as well as emergency stabilization and conservation interventions. All these priorities must also be supported by the conception and execution of substantial inclusive **capacity-building programmes for professionals** in the culture sector to cope with the brain drain of professionals and to sustain the results achieved, as all these operations require skilled specialized professionals in topography, geophysics, land survey, emergency rescue campaigns, archaeology, and conservation.

## Limitations and Recommendations for Future Assessments

The Culture's assessment is based on progressive satellite imagery analysis, with 8 July 2023 as the cut-off date, and data from the State Agency for Tourism, oblasts administration entities, research institutions, and cultural NGOs. According to the evolving footprint of the flood over time, a variable area of the four oblasts of Kherson, Mykolaiv, Dnipropetrovsk, and Zaporizhzhia is accounted for in case of damage, while losses further include Odesa, in addition to the afore-mentioned oblasts.

Lack of ground truthing for several assets and the level of damage being based largely on reports from various sources might affect the assessment in somewhat non-consistent views. Quality damage assessment could not be fully provided at this stage, as it relies on several factors only identifiable through ground data, among which the quality of the building fabric and the structural loadings of the buildings, and consistency/conditions of collections. Privately owned built heritage could not be included. ICH and CCI, at this stage, are very fairly included in the data analysis and collection (4), beyond generic assessments and assumptions based on similar situations elsewhere and RDNA2 trends. Additionally, quantitative data on the loss of human resources in the cultural sphere remains insufficient for calculating the necessary recovery measures for cultural institutions.

# Housing

## Summary

**The total damage to the housing sector is estimated at US$1.101 billion. Around 37,012 residential units were impacted by the flooding, and 15% were damaged beyond repair.** This number includes apartment units, single-family houses, and dormitories. Single-family houses have been the most affected (97.3% of damage), a finding that highlights the significant impact on the rural landscape of Ukraine, including peri-urban communities. The extent of housing damage is spread across only two oblasts, with Kherson (98.4% of damage) being significantly more impacted than Mykolaiv (1.6%). At the time of writing, information on the losses/damages of only Mykolaiv and the right bank of Kherson oblast are available, while the left bank, with 73% of the damage, is inaccessible due to the war. **Losses in the housing sector are estimated at US$66 million, which reflects the cost of demolition and debris removal and the Government's one-time payment**. The loss estimation does not reflect bank losses and mortgage defaults, temporary rental and shelter provision by owners, or adjusted rental income losses.

**The recovery and reconstruction needs for the housing sector amount to US$1.502 billion[21] .** Addressing housing recovery needs requires an integrated green, resilient, and inclusive approach, focusing on returning families to their homes and restoring livelihoods and services. There is an urgent need to provide temporary rentals for displaced households, undertake winterization, repair partially damaged residential buildings, and establish a housing reconstruction and recovery strategy and implementation mechanism. The principal areas affected are low-lying and susceptible to future flooding, so reconstruction should enhance resilience of housing stock by improving land use planning, construction technology (for example by replacing clay foundations with cement ones to increase resilience to future flood events), and thermal performance of buildings.

## Context

**Ukraine had a total of around 18 million housing units prior to the war.** Residential units are located in multi-family apartment buildings, single-family houses, and dormitories, with considerable variation across urban and rural areas. Apartment buildings are predominant in urban areas and cater to almost 67 percent of the urban population. In big cities, this share increases to 79 percent. Single-family houses, which include individual homes, dachas, garden houses, and country houses, are largely located in rural areas. In cities, single-family housing is limited to individual and garden houses and can be found in areas zoned specifically for individual and blocked houses.

**Multifamily apartment buildings in Ukraine were mostly constructed during the Soviet era and are severely aging;** less than 12 percent of Ukraine's housing stock was constructed after 1991. The aging building stock in Ukraine has also been contributing to high energy consumption, as older buildings do not incorporate energy-efficient structures and codes.

**Almost 94 percent of the housing in Ukraine is privately owned, and only 3.5 percent of households live in private rental housing.** In Ukraine, 93.7 percent of the housing stock was private as of 2013, a reflection of the privatization of housing stock that took place in the 1990s. As of 2013, only 3.4 percent of households lived in rental housing. According to housing experts and local consultations, however, this official number does not capture the real picture of the rental market. The rental process in Ukraine is often informal, and households are seen to rent out rooms in apartments as opposed to entire apartment units.

A common building material in the area is clay which is not resilient to water submersion. Rural and peri-urban houses contain little, if any, cement and so the damage in partially flooded houses is significant. The impacted areas vary considerably from rural farming communities of self-built houses, often using clay and natural materials, through more substantial peri-urban and larger villages made from brick to multi-story and modern houses in Kherson city. Kherson City was the main service provider for all affected areas. A modern city with thriving markets and building materials and skilled engineers, architects, and builders. However, as the city had been under occupation and shelled for many months, these skills have been depleted, and the market was severely restricted.

21. Both Mykolayiv and Kherson oblast sustained significant damage due to the conflict however overlap is minimal due to the predominance of rural and peri-urban areas affected by the flooding and the significant number of single dwelling houses impacted (97.3% of damage is in single dwelling houses). Damages due to the war have been deducted from the total flood damages.

In the rural areas of the flood-affected oblasts, houses are built using brick or clay with limited foundations. Larger villages and peri-urban areas are more substantial brick-and-mortar houses where the houses are more modern and larger. The building technique for multi-story buildings varies and is often related to age — pre and post-1991. Commonly pre-1991 is panel construction where the panels are load-bearing tied together for stability, while post-1991, more modern slab, and reinforced column construction are widely seen.

## Disaster Effects

The dam break created two areas of damage. The first and most significant was on both sides of the Dnipro River downstream from the dam. Water surging down the river was carrying large pieces of debris, causing extensive damage to the housing sector. Following this destructive surge, water levels rose on both sides of the river and backed up the tributaries, including the inlets, which drain from Mykolaiv, causing a second area of damage. Standing water in both areas soaked into foundations, floors, walls, and ceilings, destroying houses, and causing significant long-term damage, including outhouses and basements.

When the flood water started to rise, families left their homes with what they could carry and moved to higher ground to live with friends and family. As soon as they could, they returned as the majority derive a livelihood from the land, and so needed to return for livestock and fields.

The elderly, often living alone, were heavily impacted as they are less mobile, and once back, the work of debris removal, immediate repair, and coping with the aftermath has been significantly more challenging.

If the house is still standing, on return, the first task is to start the drying process by fully ventilating the property, usually naturally but also mechanically. Household items are dried outside and, as much as possible, are salvaged.

As far as possible, families need to continue to live on their land regardless of the state of the house, as their livelihoods are directly linked to the land. Immediate repairs on roofs and windows to weatherproof the houses enable families to live again in the house despite the structural damage. This is only possible as the flooding happened during mid-summer; the impact would have been significantly worse if it happened during winter.

## Damage and Loss [22]

**The flood water following the dam break is estimated to have caused approximately US$1.101 billion in damage to the housing sector.** A total of 51,283 buildings were submerged, covering approximately 7.4 million square meters within the affected area. Of around 37,012 housing units damaged, 15% percent were deemed completely destroyed, and 10% percent were partially damaged (Table 8). The calculation of damage started with flooding estimates from satellite images and eyewitness accounts. Three categories of flooding were created; lightly flooded, flooded between 1 and 3m, and totally submerged. A corresponding percentage of reconstruction costs was applied to each category, with 10% for lightly flooded repairs, 40% for partially flooded houses, and 100% of reconstruction costs for fully submerged houses. Reconstruction costs are based on Governmental rates for reconstruction as agreed with the World Bank and used in the RDNA.

**Housing damage varies across the three housing asset classes identified in the RDNA (apartment units, single-family houses, and dormitories).** Single dwelling houses have been most impacted (97%), followed by apartment units (3%), indicating that the flooding has mainly impacted rural and peri-urban areas along the Dnipro River rather than high-density urban areas.

**The flooding has only affected two oblasts, Kherson and Mykolaiv;** however, Kherson suffered the brunt of the damage, where 98.4% of the flooding occurred.

**Unlike damage related to the conflict, flood damage has caused significant destruction and damage to basements,** as regardless of the level of flooding within the home or building, the basement will always be flooded and so damaged. The total damage to basements is estimated at US$122 million. Most of the area uses septic tanks rather than sewerage systems, and again, unlike conflict, these may be damaged and will need repair. An allowance has been made for war-damaged houses included in the RDNA 2. The RDNA 2 analysis of housing sector damages is based on the database of the damages caused to the housing sector prepared by the Ministry of Restoration of Ukraine. Deducting this damage from the flood damage was undertaken using indirect methods of analysis through the comparison of

22. The analysis was produced using data provided by EMITTER project, which is realized under the financial support of the European Union. Its contents are the sole responsibility of the project and do not necessarily reflect the views of the European Union.

the database on war damages owned by the Ministry and the satellite analysis database.

**Losses in the housing sector are estimated at US$66 million, as shown in Table 10.** Losses reflect the cost of demolition and debris removal and the one-time payment by the Government. The removal of debris costs, on average, US$522 per house across all levels of damage, including homes that have to be completely demolished. The loss estimation does not reflect bank losses and mortgage defaults, temporary rental and shelter provision by owners, and adjusted losses in rental incomes. It is likely that the losses in the sector are higher than estimated, particularly for rental income losses. Because the rental market is mostly informal, it is not possible to collect precise data at this stage. [23]

23. An assessment is proposed to be carried out by the Ministry for Communities and Territories Development together with the Ministry of Social Policy.

**Table 8:**
**Damage inventory by asset type as of July 2023**

Source: Assessment team. Note that 37,012 properties were damaged and that the figure 56,670 also includes non-residential outhouses

| Asset type | Partially Flooded (Lightly damaged) 10% reconstruction | | Flooded (Partially damaged) 40% reconstruction | | Totally Flooded (Completely de-stroyed) 100% reconstruction | | Total damaged assets |
|---|---|---|---|---|---|---|---|
| | Units | Share (%) | Units | Share (%) | Units | Share (%) | |
| Apartment units | 914 | 91% | 57 | 6% | 30 | 3% | 1,001 |
| Single-family house | 26,949 | 75% | 3,700 | 10% | 5,361 | 15% | 36,010 |
| Dormitories | 1 | 100% | - | - | - | - | 1 |
| Sub-Total | 27,864 | | 3,757 | | 5,391 | | 37,012 |
| Outhouses | 12,021 | 61% | 2,278 | 12% | 5,359 | 27% | 19,658 |
| **Total** | **39,885** | | **6,035** | | **10,750** | | **56,670** |

**Table 9:**
**Damage by oblast as of July 2023**

Source: Assessment team. Note: Housing units include single-family houses, apartment buildings, and dormitories; outhouses are included in costs but not in units.

| Asset type | Damage to housing units | | | | | | Damage (US$ million) |
|---|---|---|---|---|---|---|---|
| | Total (number) | Total (share %) | Urban | | Rural | | |
| | | | Number | Share% | Number | Share % | |
| Kherson | 36,428 | 98.4% | 21,857 | 60 | 14,571 | 40 | 1,073.92 |
| Mykolaiv | 584 | 1.6% | - | 0 | 584 | 100 | 27.28 |
| Dnipropetrovsk | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zaporizhzhia | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **37,012** | **100%** | **21,857** | | **15,155** | | **1,101.18** |

**Table 10:** Losses inventory by category (US$ million) as of July 2023

| Loss category | Loss amount (US$ million) |
|---|---|
| **Cost of demolition and rubble removal** | **61.27** |
| One-time Government Payment (including for left bank) | 4.39 |
| **Total** | **66.60** |

Source: Assessment team. Note that the cost of replacement furniture is included in the damages and not in the losses. The cost of demolition is calculated as 14.75% of the cost of reconstruction (dependent on the level of damage), and the rubble is set at 3.125%.

## *Reconstruction and Recovery Needs, including Build Back Better*

The total needs for the housing sector are US$1.502 billion, with US$722 million needed in the immediate to short-term (Table 11). This amount would allow for the design and implementation of more detailed assessments of the housing stock affected by the flooding, assist owners of lightly damaged residential units to conduct repairs and establish support systems to facilitate longer-term repair and reconstruction.

There is an urgent need to provide temporary rental housing in the private sector for displaced households, undertake winterization, repair partially damaged residential buildings, and establish a housing reconstruction and recovery strategy and implementation mechanism. Significant relocation is not expected unless families chose to relocate, as the area is still under threat from shelling. Particularly, providing repair and rental subsidies before cold, wet weather begins will mitigate further displacement and fragility risks. There is a need to establish a framework for housing reconstruction and recovery in the medium term. These actions can begin immediately and will allow for the appropriate sequencing of key actions and the planning of budgets accordingly. Several actions taken in the immediate/short term can safeguard households, kick-start recovery, and provide a base for longer-term recovery. For example: (i) ensure households' safety and adequate housing through repairs, provision of rental support for IDPs and returnees, and establishment of safety nets (cash transfers, urban services, etc.); (ii) elaborate a strategic framework for green, resilient, and inclusive recovery and reconstruction for the housing sector at the central, oblast, and district levels, setting the stage for longer-term recovery and reform of the sector; and (iii) ensure support to households/beneficiaries through training, capacity building, and adequate technical assistance.

**Repair and reconstruction are critical to ensure a swift return and kick-start recovery:**

- **Repair support for partially damaged housing units.** As of July 2023, it is estimated that 85 percent of the affected housing units have been partially damaged and are unlikely to require full demolition and reconstruction. Although the immediate damage of the flooding should be repairable, unforeseen structural and foundational damage may only become apparent during the next winter and a freeze-thaw cycle.
- **Reconstruction of fully destroyed housing units.** Fully destroyed residential buildings account for 15 percent of the damaged residential buildings, and their complete reconstruction will be slower, as these will require full demolition, full redesign, and construction. The first months will need to be dedicated to demolition, site clearance, design, and preparing engineering documents and foundation layouts.
- **Rental subsidies.** Rental subsidies aim to provide access to sustainable rental housing options for vulnerable households affected by flooding to minimize the risk of displacement and unsafe houses which may collapse when winter arrives. Subsidies can help prolong hosting arrangements and keep the displaced in regular housing while repairs of damaged residential buildings are underway. These rental subsidies can be in the form of cash support to allow renting directly in the market and support to allow host communities and families to absorb displaced families and individuals.
- **Demolition and debris removal.** Demolishing and removing debris from destroyed and damaged buildings are critical to begin safeguarding the

population and to ensure quick and safe commencement of repairs and reconstruction, and thus return of households to their places of residence.

- **Winterization.** This includes full building-shell winterization to ensure that windows and doors are in place and that cracked walls, openings, and pipes are repaired to reduce risk of degradation due to winter freezes. Winterised habitable structures, even damaged ones, can be used for temporary housing.

**In the medium to long term, complementary activities addressing the full value chain of the housing sector should be undertaken to ensure its full recovery.** The following topics can be entry points for longer-term development:

- **Facilitate remittance sending.** Develop secure arrangements within the banking sector to incentivize remittance sending for housing recovery.
- **Support materials markets.** Undertake upstream work with suppliers and distributors to ensure the availability of construction materials to facilitate repair and reconstruction and help to manage bottlenecks in building materials pipelines.
- **Support green reconstruction.** Provide just-in-time technical assistance and advice to enable contractors to use green materials and approaches fitting with the updated green and energy-efficient building regulations.
- **Support labour markets.** Address labour constraints in construction and engineering services, including awareness and capacity building of engineers and construction workers in disaster-resilient construction.
- **Protect low-income tenants and owners.** This protection is necessary considering the shadow economy and given the lengthy administrative processes that make tenancy and ownership unclear and difficult to access. It can be provided through specific affordable housing programs.
- **Improve access to housing finance for low-income groups.** This access can be improved by bolstering credit markets, providing resources to increase the liquidity of both traditional lenders and microlenders, and mitigating credit risks.
- **Promote private sector inclusion through public-private partnerships.**

| Needs category | Immediate term | Short term | Total (immediate and short-term) |
|---|---|---|---|
| **Housing assessments** | 1,503,055 | 7,074,735 | 8,577,791 |
| Conduct in-depth building inspections (to determine habitability) | 165,203 | 385,474 | 550,677 |
| Conduct engineering studies of individual residential buildings | 1,337,852 | 6,689,261 | 8,027,114 |
| **Organizational arrangements** | 54,640 | 229,489 | 284,130 |
| Establish planning committees (per oblast in the immediate term, then per district) | 32,784 | 163,921 | 196,705 |
| Design monitoring and reporting systems | 21,856 | 21,856 | 43,712 |
| Implement monitoring and reporting systems (national level) | 0 | 43,712 | 43,712 |
| **Coordination and technical assistance** | 32,784 | 87,425 | 120,209 |
| Prepare/validate National Housing Recovery Strategy (linked with urban recovery planning) | 10,928 | 32,784 | 43,712 |
| Undertake household enrolment, beneficiary selection, outreach, and case management | 21,856 | 54,640 | 76,496 |

**Table 11:** Recovery and reconstruction needs (US$ million) as of July 8, 2023

Source: Assessment team. Substantial awareness and capacity building of the engineers and the construction workers included in RDNA and so not duplicated here.

| Needs category | Immediate term | Short term | Total (immediate and short-term) |
|---|---|---|---|
| **Repair, reconstruction, and stabilization** | 68,286,723 | 644,907,284 | 713,194,007 |
| Provide technical assistance for immediate and short-term repairs and stabilization | 81,960 | 245,881 | 327,842 |
| Provide rental subsidies | 6,972,083 | 24,402,291 | 31,374,374 |
| Provide for demolition and debris removal | 4,881,838 | 34,504,215 | 39,386,053 |
| Provide repair and reconstruction subsidies | 56,350,841 | 585,754,897 | 642,105,739 |
| **Total** | **69,877,203** | **652,298,933** | **722,176,136** |

### *Recommendations*

Development of, and agreement on, a detailed housing recovery strategy is critical. Considering the extensive recovery needs for housing and settlements and the limited public resources, it is necessary to define a housing recovery strategy and an operational housing recovery manual that presents a set of prioritization criteria for investments. This process has started for house repair and reconstruction due to the war and now it is critical that flood areas are included in these strategies and the subsequent planning.

### *Notes on the Methodology, including Assumptions and Limitations*

To prepare this section, engineers and housing reconstruction experts visited Mykolaiv and the right bank of Kherson; however, due to the conflict, it was not possible to visit the left bank of Kherson, where most of the damage is. Field findings used to estimate the levels of damage caused by the flooding have been extrapolated to include the left bank of the Dnipro River.

Based on the three levels of flooding (partial, flooded, and totally submerged), 10%, 40%, and 100%, respectively, of the reconstruction costs were applied to the total area of the house. Reduced rates were used for basements and outhouses.

## Education

### *Summary*

**Explosion-induced flooding caused US$51.97 million in damages to 37 education institutions in Kherson and Mykolaiv oblasts, with a 54%-46% split between government-controlled and non-government-controlled (left bank) areas.** The damage cost distribution was 56.4% for secondary schools, 20.3% for preschools, and the remainder for two extra-curricular and two vocational training institutions. Estimated losses of US$3.6 million consist of 56.62% for student materials and devices, 23.78% on catch-up education, and 16.99% on teaching materials for teachers.

The impacts include severe mental and emotional harm, displacing students and educators, and leading many children to leave school. The disruption interrupts teachers' income, increases parents' and caregivers' expenses, and worsens educational inequalities.

**The reconstruction and recovery of damaged education institutions is projected at US$62.37 million (US$56.57 million short term, US$5.8 million medium term)**, complying with the Ministry of Education and Science's vision, emphasizing access to learning, engaged learners, and enabling education environment. Secondary schools represent the largest cost segment at 48%.

## Context

The final breach of the Kakhovka Dam resulted in mass flooding, impacting an estimated 46 settlements across both the right and left bank of the Dnipro River with 116,790 persons[24]. Of them, 43,400 are estimated to be school-aged children and teaching personnel[25]. 37 education institutions were damaged (Table 12).

As a result, the education sector in flood-affected oblasts of Kherson and Mykolaiv have recorded considerable damage and losses, including losses in physical assets and in the psychosocial well-being of students and educators. Before the breach, there was already prevailing learning loss, learning poverty, and an education crisis[26]. The dam destruction severely exacerbated these challenges, impacting the education system, impeding recovery from lost learning and the psychological distress of students and teachers, as well as reversing the overall country-wide progress so far made to achieve expected learning outcomes.

| Oblast | Type of Damage | Preschool | Second-ary school | Extra-curricular education institution | VET | Total | Share of total (%) |
|---|---|---|---|---|---|---|---|
| Kherson | Partial | 12 | 19 | 2 | 2 | 35 | 95 |
| Mykolaiv | Partial | 1 | 1 | 0 | 0 | 2 | 5 |
| Zaporizhzhia | No damage reported | 0 | 0 | 0 | 0 | 0 | 0 |
| Dnipropetrovsk | No damage reported | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | | **13** | **20** | **2** | **2** | **37** | **100** |

**Table 12:** Type of Education Institutions Damaged at Oblast Level

Source: Assessment team based on the data provided by the Local Education Authorities

### Pre-emergency context

A total of 4,244 institutions (1,679 pre-primary, 2,310 secondary, and 255 extracurricular) in Kherson, Mykolaiv, Zaporizhzhia and Dnipropetrovsk oblasts were providing online learning for 580,717 students and face-to-face learning for 2,641 students before the emergency[27]. Severely flood-affected Kherson and Mykolaiv represented 34 percent (1,442 out of 4,244) of functional education institutions, which were providing learning to 27 percent (154,276 out of 580,717) of children learning online and to 91 percent (2,411 out of 2,641) of children learning face-to-face (see Table 13 for details).

25. IOM. (16 June 2023). Nova Kakhovka Flooding, Needs Assessment. Kyiv: IOM-DTM.
26. It represents an estimated 42,000 school aged children and 1,400 teaching personnel.
27. Learning poverty is defined as the inability to read and understand a simple text by age 10. More information about the learning poverty measure can be found https://www.worldbank.org/en/topic/education/brief/what-is-learning-poverty.
27. Education Cluster analysis based on the data of the MoES as of May 2023.

**Table 13:** Education institutions in the flood-affected oblasts

| Oblast | GCA[28] | | | NGCA | | | Total functional institutions | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pre-school education (kindergarten) | Extra-curricular education | Secondary education | Pre-school education (kindergarten) | Extra-curricular education | Secondary education | Pre-school education (kindergarten) | Extra-curricular education | Secondary education |
| Mykolaiv | 229 | 25 | 437 | 1 | 0 | 2 | 230 | 25 | 439 |
| Kherson | 54 | 1 | 166 | 274 | 23 | 230 | 328 | 24 | 396 |
| Zaporizhzhia | 209 | 39 | 416 | 123 | 40 | 239 | 332 | 79 | 655 |
| Dnipropetrovsk | 789 | 127 | 820 | 0 | 0 | 0 | 789 | 127 | 820 |
| | **1,281** | **192** | **1,839** | **398** | **63** | **471** | **1,679** | **255** | **2,310** |

28. GCA: Government Controlled Areas and NGCA: Non-Government Controlled Areas. The source is ibid.

## *Damage and Loss Assessment*

### Damage to Education Facilities

Explosion-induced flooding has caused US$51.97 million in damage to educational institutions in Kherson and Mykolaiv oblasts (Table 14). The reported type of damage is partial to those facilities, both in government-controlled areas (GCA) and non-government-controlled areas (NGCA). In terms of territories, 54 percent (20 out of 37) of the damaged education facilities are located in the GCA, while 46 percent (17 out of 37) are reported in the NGCA. Related to the level of education, 54 percent (20 out of 37) represent secondary schools, while 35 percent (13 out of 37) are preschools. There are two extra-curricular education institutions and two vocational education and training (VET) institutions that have also sustained damage. 56.4 percent of the cost is related to secondary education facilities, while 20.3 percent is related to preschool facilities.

**Table 14:** Damage by Education Institutions (US$51.97 million) as of 30 July 2023

Source: Assessment team

| Cost of destruction of infrastructure and assets | Total value (US$ million) | Share of total (%) |
|---|---|---|
| Preschool | 10.53 | 20.3 |
| Secondary school | 29.32 | 56.4 |
| Extra-curricular education institution | 3.97 | 7.6 |
| Vocational Education and Training (VET) | 7.97 | 15.3 |
| **Cost of demolition** | | |
| Demolition of damaged facilities, removal of debris | 0.17 | 0.3 |
| **Total** | **51.97** | **100** |

## Loss to Education and Learning

Losses have been estimated at approximately US$3.6 million (Table 15). The cost of providing learning materials and devices to students stands at 56.62 percent, while the cost of providing catch-up education stands at 23.78 percent, and the provision of teaching materials and devices for teachers is 16.99 percent. To improve education in a healthy learning environment, it is necessary to create awareness of contamination and water-borne diseases coupled with mine risk education for school children and teachers.

| Category | Total value (US$ million) | Share of total (%) |
|---|---|---|
| Cost of provision of learning materials and devices | 2.00 | 56.62 |
| Cost of provision of teaching materials and devices | 0.60 | 16.99 |
| Cost of disinfection of schools and education facilities | 0.02 | 0.52 |
| Cost for conducting learning loss/interruption assessment | 0.06 | 1.57 |
| Cost of provision of catch-up education | 0.84 | 23.78 |
| Awareness raising on water contamination and water-borne diseases for school children and teachers | 0.02 | 0.52 |
| **Total** | **3.53** | **100.00** |

**Table 15:** Losses to education of approximately US$3.6 million as of 30 July 2023

Source: Assessment team

## *Human and economic Impacts*

The impact on the education sector has significant human and economic dimensions, with damage to mental and emotional well-being and displacement of students and educators. Many children have left school, resulting in interrupted income for teachers, increased expenses for parents and caregivers, and exacerbation of existing educational inequalities.

## *Reconstruction and Recovery Needs, including Build Back Better: Enabling Quality Learning*

**The reconstruction and recovery of damaged education institutions are expected to cost US$62.37 million (Table 16).** The reconstruction process must comply with the vision of the Ministry of Education and Science (MoES),[29] which spells out the key priority areas, including school children, teachers, content, financing, and learning environment. Improving the learning environment should entail equipping all institutions affected by explosion-induced flooding with bomb shelters[30], readying them for winter (e.g., providing generators), and rehabilitating them with power/internet connectivity and educational equipment for multiple learning modalities, online, in-person, and mixed methods. The future education system will need to take into account the ongoing war and its targeting of critical infrastructure and education institutions[31].

The reconstruction and recovery of the education sector is linked to enabling learning. Enabling learning is the result of a combination of elements, including access to learning, engaged learners, and an enabling education environment.

29. MoES. (July, 2023). The Vision for the Future of Education and Science of Ukraine. Ministry of Education and Science, Retrieved from https://mon.gov.ua/storage/app/media/Viziya.maybutnoho.osvity.i.nauky.Ukrayiny/12.07.2023/Viziya.maybutnoho.osvity.i.nauky.Ukrayiny-12.07.2023-2.pdf

30. The Ministry of Education and Science is preparing for in-person education with the start of new academic year in September 2023. Reopening for in-person mode of learning in condition with having safe bomb shelters at schools.

31. To see the latest situation on attack related to education facilities, please, refer https://saveschools.in.ua/en/

Figure 9: Building back better: enabling learning for all


**Access to learning** refers to access to schools for face-to-face learning by reconstruction of education facilities, establishment of safe bomb shelters at schools[32], expanding learning platforms including for children on the frontline, provision of technological tools (computers, tablets, and smartphones) and a reliable internet connection and availability of materials for remote learning, or appropriate combinations of these for hybrid learning.

**Engaged learners** focuses on provision of psychosocial support, learner-centred activities and materials (appropriate for learners' age and capabilities and enabling the development of social-emotional and life skills as well as foundational skills), supported by effective pedagogy and flexible curriculum to cope with ongoing war and its impact on learning, effective teachers (whose approach is centred on the learners) and engaged parents/caregivers who provide both support and feedback including on which mode of learning depending on rapidly changing war context is good for their children to continue learning amidst the ongoing shelling and targeted attacks on education facilities.

**Enabling environment** consists of making sure of availability of agile education leadership at the locational and national level for facilitating a safe school/home environment for continuity of learning, providing support to teacher preparation, ongoing professional development for teachers (including skills for effective in-person teaching, online learning, when schools are not ready for in-person education/hybrid teaching), effective leadership and management (including clear communication with stakeholders) and strong monitoring and evaluation systems (including learning assessment) to enable ongoing provision of learning that meets the needs of all learners.

32. Please, refer the recommendations to establish bomb shelters at the schools https://mon.gov.ua/ua/news/bezpeka-pid-chas-navchannya-rekomendaciyi-shodo-organizaciyi-ukrittya

Table 16: Recovery and reconstruction needs (US$62.37 million) as of July 30, 2023

Source: Assessment team

| Category | Description | Short-term (US$ million) | % | Medium- to Long-term (US$ million) | % | Total (US$ million) | % |
|---|---|---|---|---|---|---|---|
| **Access to learning: reconstruction of education facilities** | Reconstruction of Preschool | 10.53 | 18.62 | 2.00 | 34.52 | 12.53 | 20.10 |
| | Reconstruction of Secondary school | 29.32 | 51.84 | 0.75 | 12.95 | 30.07 | 48.22 |
| | Reconstruction of Extra-curricular education institution | 3.97 | 7.03 | 0.02 | 0.32 | 3.99 | 6.40 |

| Category | Description | Short-term (US$ million) | % | Medium- to Long-term (US$ million) | % | Total (US$ million) | % |
|---|---|---|---|---|---|---|---|
| **Access to learning: re-construction of education facilities** | Reconstruction of Vocational Education and Training (VET) | 7.97 | 14.08 | 0.06 | 0.96 | 8.02 | 12.86 |
| | Demolition of damaged facilities, removal of debris | 0.17 | 0.30 | 0.84 | 14.50 | 1.01 | 1.62 |
| | Establishment of safe bomb shelter | 2.59 | 4.58 | 0.02 | 0.32 | 2.61 | 4.18 |
| **Engaged learners: restoration of learning** | Cost for conducting learning loss/interruption assessment | 0.06 | 0.10 | 0.06 | 1.01 | 0.11 | 0.18 |
| | Cost of provision of Catch-up education | 0.84 | 1.48 | 0.89 | 15.22 | 1.72 | 2.76 |
| | Psychosocial support for children | 0.95 | 1.67 | 0.99 | 17.13 | 1.94 | 3.11 |
| | Psychosocial support for teachers | 0.01 | 0.25 | 0.15 | 2.54 | 0.29 | 0.46 |
| **Enabling environment: improving Resilience of Education System** | Equipping the local education authorities to respond to and recover from emergencies | 0.02 | 0.04 | 0.02 | 0.36 | 0.04 | 0.07 |
| | Capacity building of Local Education Authorities | 0.01 | 0.02 | 0.01 | 0.18 | 0.02 | 0.03 |
| **Total** | | **56.57** | **100.00** | **5.79** | **100** | **62.36** | **100** |

## *Key Recommendations to revitalize and restart the Education sector including to Build Back Better.*

### Access to learning

- Strengthening a range of learning modalities is urgently needed for to ensure that all students have access to both learning and education services to support their wellbeing.
- Restoration of learning and provision of education should adapt multiple pathways of learning—online, in-person and mixed methods of learning. For this, building capacities of teachers, and supporting children with required materials and devices are provided with flexible learning modality and assessment.
- The education system, with the engagement of affected community, should support children to recover from learning loss and promote catch up education at the right level.
- Pre-existing learning disparities and learning losses are growing, suggesting a strong need for differentiated interventions and targeted resources for those who are at a disadvantage, and innovative techniques including teaching based on the learning level of a child.

### Engaged learners

- Take urgent action to provide remedial, and social emotional learning for all learners in the affected oblasts to prevent a potential learning catastrophe from the combined ongoing war and dam destruction effects.
- MHPSS for students and teachers need to be prioritised and integrated into curriculum to sustain the investment for longer period.

### Enabling environment

- The reconstruction process should invest in education system strengthening in order to facilitate education for children and leave no one behind as a consequence of the on-going war.

## *Notes on the Methodology including Assumptions and Limitations*

The sector analysis is based on the data sourced from the Local Education Authorities and Education Cluster. Based on the data available, the scope of the assessment was decided, and further detailed data analysis was conducted. This was followed by meetings with the respective authorized stakeholders who, in most cases, were the custodians of data received.

The limitations and assumptions include:

- No data available for assessing the situation in the NGCA. Based on the preliminary data received by the location education authority, and based on the experience of the Education Cluster, the number of children and teachers were estimated.
- For psychosocial support for children and teachers, the estimated number of affected students can be calculated using the children population and pre-higher and higher education student populations in the most affected oblasts (39,600 in Kherson, and 2,400 in Mykolaiv, totaling 42,000). The assumptions could be that 25% of these will need 5 individual sessions and 50% of these will need 5 group sessions.
- It is estimated that 1,400 affected teachers will need psychosocial support. Assumptions include 25% would need 5 individual sessions and 50% would need 5 group sessions.
- Cost estimates were made based on the assumptions used in the RDNA-2. This is the case for all activities included in this assessment. This was fact-checked with the Education Cluster costing and key UN agencies including UNICEF.


# PRODUCTIVE SECTORS

# Agriculture

## Summary

**Total damage and loss to the agriculture[33] sector because of the Kakhovka dam burst is estimated at US$406.6 million.** Most of the damage and losses in the agricultural sector were attributed to crop production, at US$376.7 million (92%), primarily due to the disruption of irrigation. Damage and losses to fishery and aquaculture comprised 8% of the total at US$31.5 million. Damage related to livestock production constituted the remaining US$0.24 million. These estimates, particularly damage, should be considered an underestimation due to a lack of data. Further, damage and losses on occupied territory remain unknown. Still, due to the flood extent and significance of agriculture in the local economy, they are likely to exceed those in areas of Ukrainian control.

In the aftermath of the destruction of the Kakhovka dam, the situation for rural farming households in Ukraine has worsened. They were already experiencing income declines due to war-related disruptions in agriculture and increased production costs. Households in front-line areas displayed lower economic diversity and higher dependence on aid. The dam's destruction had multiple impacts – flooding has obliterated crops, the reservoir has drained out, depriving crops of irrigation for years, and fisheries have been devastated. People employed in state-owned irrigation and aquaculture enterprises confront sudden unemployment. Declining household incomes, reduced harvests, damage to subsistence farming plots, and the cessation of local fisheries can cause fluctuations in local food prices and availability, threatening household dietary diversity and increasing food insecurity. The absence of irrigation in the wake of the dam destruction could have notable macroeconomic repercussions. Over 306,500 hectares of cropland will transition to rainfed irrigation, decreasing yield by 70%, as well as loss of all prospects for two harvests (interchanging of cereal and oil crops) on the irrigated land. In 2021, this irrigated land produced 2 million tons of grain and oilseeds. Production will now largely depend on unpredictable rainfall due to global climate change and potential micro-climate shifts from reservoir draining. The total loss of fishing in the reservoir, river, and delta will considerably affect the fishery sector, with the estuary and delta comprising 13.1% of Ukraine's 2021 fish catch.

**The estimated agriculture sector recovery needs amount to US$180 million over ten years, of which US$69.5 million is required in the immediate/ short-term.** To maintain agricultural production, several measures are essential. Support must be provided to farmers with flooded land to restore crops and livestock production, and crop farmers must reduce reliance on surface irrigation by introducing new water sources and methods. Livestock farmers need alternative water solutions, and restoration of flood-damaged infrastructure is vital. Recovery of fish populations in affected areas requires particular attention, and farmers losing access to irrigation need help reconsidering cropping patterns, with incentives for using drought-resistant crops. Addressing liquidity issues by providing access to finance and innovative investment tools is crucial, along with a comprehensive monitoring program to ensure the health and markets of producers affected by contamination and infrastructure failure.

## Background

The flooding spread across both banks of the river, but due to the topography, more flooding was experienced on the flatter left bank, currently occupied by the Russian Federation. This area comprises the vast majority of affected rural residents and agricultural land, as well as one-third of the affected households, however there is a dearth of information from the affected occupied territories and the full extent of damage is still largely unknown.

The Kakhovka reservoir served as the water source for a vast agricultural irrigation network, with the capacity to feed 800,000 hectares of cropland. Within a few days of the dam breach, the water level was already too low to feed the irrigation canals. Within a few weeks, the reservoir was nearly dry.

Due to the proximity to the front line, much agricultural production had already diminished or ceased in the previous year – parcels of cropland were abandoned,

33. The agriculture sector includes crops, livestock, fishery, and aquaculture. Irrigation is included in the crop production sub-sector. This report covers forestry under the Environment sector as forests in the affected area are non-productive.

fishing activities restricted. Damages amongst rural households for the first six months of war were already estimated at US$1.26 billion nationally for crops and nearly US$1 billion for livestock[34]. The consequences of the dam burst will complicate, compound, and lengthen the possibilities for recovery of agricultural livelihoods in the region.

## Crop production

Before the start of the war, the four oblasts of Dnipropetrovsk, Zaporizhzhia, Mykolaiv, and Kherson comprised about one-quarter of all cultivated agricultural land in Ukraine and about one-fifth of harvested production[35]. The region produced a wide variety of crops, including more than 40% of Ukraine's production of winter barley, and more than 20% of national production of winter wheat, rapeseed, sunflower, and spring barley.

The majority (more than 85%) of small agriculture enterprises in the affected areas focus on crop production, in particular the intensive production of cereals and oil crops, while the remainder engage in livestock or mixed crop and livestock production5. Due to the microclimate and the availability of irrigation, winter cereals are often paired with oil crops resulting in two harvests per year.

Prior to Russia's full-scale invasion of Ukraine, the area was also a main supplier of fruits and vegetables, enabled by the presence of irrigation systems relying on the Kakhovka dam. Nearly 95% of irrigation systems in Kherson, 75% in Zaporizhzhia, and 30% in Dnipropetrovsk oblasts are supplied by the Kakhovka reservoir, which was feeding four major irrigation channels. In Kherson Oblast, tomatoes, cabbage, onions, bell peppers, and eggplants are the most widely grown vegetables, in addition to fruits such as watermelons and stone fruits.

Risks to agricultural land or soils due to contamination or similar issues are considered in the Environment chapter of this report.

## Livestock

The livestock sector is important both as means of adding value to primary crop production as well as to support livelihoods of Ukraine's smallholder farmers and households. Most of the ruminants in the country are kept by smallholders, while most of the pigs and poultry are kept by enterprises.

The enterprise segment accounts for some 4,000 entities that on average keep about 900 Animal Units worth of livestock. With the start of the war, livestock enterprises accounted for total of US$1.13 billion in damage and loss, of which losses account for 80.4% of the total value[36].

Livestock production at household level declined by 5.5–22 percent after the start of the war, depending on the species. The value of lost animals constituted overall damages of approximately US$250 million, mostly driven by slaughtering and destocking as a coping strategy. Total damage and loss to household livestock production after the first eight months of war was estimated at US$0.98 billion[37].

## Fisheries

Traditionally, fishing has been a significant economic activity in the four affected oblasts, especially marine and brackish water capture fishing in the Odesa delta, Black Sea, and Sea of Azov. At the same time, in recent years the importance of fishing activities in the Kakhovka reservoir and Dnipro River increased because of the limited access of fishermen to fishing grounds in the sea and river due to the war.

After the start of the war and prior to the dam collapse, on national level approximately 36 percent of the commercial fishers in inland fisheries and deltas were unable to engage in activities for more than half of the 2022 season. This included the entire length of the Dnipro River starting from the Kakhovka reservoir to the delta, with devastating effects due to complete inactivity of the marine fishing fleets in 2022. The financial impacts on the fishing sector in 2022 account for almost the entire total catch in the Black and Azov Sea (13,000 tons of sea products, valued at USD 10.5 million) and a significant share of the country's largest inland fisheries evaluated as a loss of USD 8.2 million[38]. Data on damages to fisheries assets (e.g. boats, gears, and fishing infrastructure) was not available.

The fishing activity in the reservoir thus became of great importance for food security and livelihoods in Ukraine and was undertaken by 49 fishing companies, commonly comprised of several vessel owners, including the involvement of 110 vessels, predominantly small boats less than 15 miters. Fishing in the Kakhovka reservoir accounted for 7.8% of the total fish catch (2,373 tons)

34. FAO. 2022. Ukraine: Impact of the war on agriculture and rural livelihoods in Ukraine – Findings of a nation-wide rural household survey, December 2022. Rome. https://doi.org/10.4060/cc3311en

35. State Statistics Service of Ukraine, 2020

36. FAO. 2023. Ukraine: Impact of the war on agricultural enterprises – Findings of a nationwide survey of agricultural enterprises with land up to 250 hectares, January–February 2023. Rome. https://doi.org/10.4060/cc5755en

37. FAO. 2022. Ukraine: Impact of the war on agriculture and rural livelihoods in Ukraine – Findings of a nation-wide rural household survey, December 2022. Rome. https://doi.org/10.4060/cc3311en

38. FAO. 2023. Ukraine – Damages and losses in the aquaculture and fishery sectors: Report on the impact of the ongoing war, January 2023. Rome. https://doi.org/10.4060/cc4018en

in Ukraine in 2021 and 13.5% of the inland fish catch and employed approximately 340 persons directly as fisherfolk. Fishing in the estuary and delta areas accounted for 13% of the national fish catch in 2021 and was carried out by 36 fishing companies.

## Aquaculture

Aquaculture activities were undertaken in 2021 by 151 aquaculture farms in four affected oblasts[39]. Most focused on producing cyprinid (various types of carp) for local consumption, meanwhile biggest aquafarms were focus on production of Sturgeon, Silver Carp and Grass Carp fingerlings and fry for restocking of the Dnipro River and reservoirs.

The effects of the war on the aquaculture sector were diverse, ranging from direct damages to production (assets and e.g., broodstock) to disruptions in logistics. Overall, 11 percent of farms reported damage to assets. The overall damage to the sector in 2022 totaled US$4.97 million, while the losses of breeding stock in state farms totaled US$16.6 million.

Kherson oblast had 2 state-owned fish farms, which ensured the maintenance of valuable broodstock of carp, sturgeon, and other species of fish, as well as raised and introduced valuable fish species into natural reservoirs for the support of aquatic ecosystems, formation of industrial reserves, important fish farming and melioration activities. The production capacities of these fish farms are currently lost, as well as valuable breeding material, including sturgeon species.

Ukraine practices culture-based fisheries, which is a common technique of managing fish stocks in natural and artificial waters. This includes science-based restocking of younger generations of fish species that are widely captured by sport, subsistence, and commercial fishers, supporting both food security and livelihoods of the local population. The farms thus supported the restocking of fish in the reservoir as well as the entire Dnipro River. With the damages to the aquaculture farms in the wake of the dam collapse, the sustainability of the entire Dnipro fisheries is affected at the short and future sustainability in the long term at question.

# *Damage and Loss Assessment*

**Table 17:** Overall estimated damage and losses (in USD) by agricultural sub-sector

| Sector | Damages (USD) | Losses (USD) | Total (USD) |
|---|---|---|---|
| Crops | 3,144,774 | 373,524,547 | 376,669,321 |
| Livestock | 109,020 | 133,560 | 242,580 |
| Aquaculture and Fisheries | 22,700,453 | 9,052,715 | 31,753,167 |
| **Total** | **25,954,247** | **382,710,821** | **408,665,068** |

## Crops sector

The effects of the Kakhovka disaster on the crops sector can be classified largely into two categories:

- Direct flooding affecting households and cropland along the river and damage to irrigation-related assets and;
- Shortage of water needed for agricultural irrigation systems in the southeastern macro region.

Approximately 1,000 hectares of cropland were flooded on both sides of the Dnipro River according to an FAO geospatial assessment. Since waters receded several days later, all inundated annual standing crops are considered lost without possibility for replanting due to the inaccessibility of the land. The estimated loss of standing crops has been evaluated at some US$0.6 million. In addition to the flooded open fields, an estimated 1,144 rural households experienced flooding of

39. FAO. 2023. Ukraine – Damages and losses in the aquaculture and fishery sectors: Report on the impact of the ongoing war, January 2023. Rome. https://doi.org/10.4060/cc4018en

their small plots and kitchen gardens, which were used mainly for subsistence production of fruits and vegetables. Based on government reports and the results from an FAO assessment[40], an estimated 378 hectares are affected, amounting to a loss of US$4.37 million.

| Loss | Hectares | Losses (USD) |
|---|---|---|
| Yield difference due to lost irrigation | 243,652 | 368,541,790 |
| Flooded cropland | 1,000 | 611,588 |
| Flooded household kitchen gardens | 378 | 4,371,169 |
| **Total** | | **373,524,547** |

**Table 18:** Estimated losses (in USD) by type in the Crops sub-sector

A remote sensing analysis conducted by FAO indicates that irrigated areas of about 243,600 hectares across all four irrigation systems are expected to experience a reduction of yields due to the now-defunct irrigation system. These losses are estimated at US$184.3 million per year for both 2023 and 2024.

The disruption of irrigation will also lead to significant reduction in the aquifer water table as well as increasing salinization. Desertification of arable land in the south-east is also likely, however these effects are beyond the scope of this report and require further research.

Damage to assets of US$3.14 million has been estimated on the basis of flooding of pumping stations that supply irrigation channels and reparation of physical damages to infrastructure. There is currently no information on the effects of the dam destruction on other crop related infrastructure, equipment, and mechanization (e.g., greenhouses, tractors, harvesters, pumps, drip irrigation systems), stored products, or agricultural inputs.

Selected interviews with crop producers in the affected area indicated that, in the wake of the disaster, lower yields are likely as farmers expected to reduce their sowing rate (by up to 30%) and produce only one harvest per year due to the lack of irrigation. Vegetable farmers noted a need for boreholes, wells, and drip irrigation to maintain production.

## Livestock sector

Damage to the livestock sector has been estimated on account of available data on animal deaths among rural households, as reported by authorities representing approximately one-fifth of affected rural households. Losses are derived from reduced production and additional treatment costs for injured animals. The documented damages and losses are estimated at US$242,580.

The destruction of the dam resulted in limited damages to the livestock population, considering the extent of the floods and the low livestock populations in the directly affected areas. However, the loss of functional irrigation channels will also cause a significant reduction in the underground water table, which supplies drinking and technical water. In addition, the drastic reduction of the water level in the weeks after the dam destruction will limit the sustainability of livestock production on significant portions of the three most affected oblasts.

40. FAO. 2022. Ukraine: Impact of the war on agriculture and rural livelihoods in Ukraine – Findings of a nation-wide rural household survey, December 2022. Rome. https://doi.org/10.4060/cc3311en

**Table 19:** Estimated damage and losses (in USD) by livestock type in the Livestock sub-sector

| Livestock type | Damages (USD) | Losses (USD) | Total (USD) |
|---|---|---|---|
| Bovines | 4,000 | 99,000 | 103,000 |
| Apiaries | 96,600 | 32,200 | 128,800 |
| Others | 8,120 | 2,260 | 10,380 |
| **Total** | **109,020** | **132,200** | **242,580** |

## Aquaculture and Fisheries sector

As the Kakhovka reservoir drained, the aquatic life was either exposed due to retreating waters or washed away downstream. This resulted in almost complete destruction of the fish population and total idling of fishing activities. The water habitat of aquatic plants and animals is confined to the now-diminished water levels in an area that is only 12,7% of the original area, leading to an imbalance in the ecosystem downstream and the potential loss of some species.

In the Dnipro-Bug estuary and Odesa delta, the destruction of the dam resulted in a temporary increase in flow, leading to flooding of the coastal areas during the spawning season. The resulting increased water turbidity and potential damage[41] from toxic sediments on ova, fry, and larvae have led to an estimated loss of a minimum of 25-50% of fish and fry populations, which have either been washed away, destroyed, or forced to move to tributary waters.

The available information indicates that the total value of losses to fisheries in the reservoir, river, and delta amounts to around US$9 million. Damages to the fishing fleets, equipment, and infrastructure could not be calculated due to a lack of information.

The losses in the Kakhovka reservoir total US$5.2 million and account for the total commercial fish population on the basis of the pre-war statistical data, of which 60% are losses to fish populations not subject to fishing quotas. The losses for the Dnipro-Bug estuary system and the Odesa delta are evaluated at US$3.8 million and include the expected reduction in the fish population by 50% and 25%, respectively, as well as the loss of fishing quotas for 2023 and 2024.

In addition, traces of light contamination with toxic and radioactive elements have been documented in samples from the soil and water, with potentially hazardous effects on human health, indicating the need for monitoring programme of the water, aquatic food products, and crops produced in the area.

In the aquaculture sector, the damages from the Kakhovka dam disaster translate into damages as a result of flooding, which affected aquaculture farms on the banks of the Dnipro River and the drying up of irrigation channels supplying water to inland aquaculture farms.

Three affected state farms, which produced fingerlings of sturgeon and carp in support of the culture-based fisheries of the Kakhovka reservoir and Dnipro River, were confirmed to be damaged by flooding. The replacement of dead stocks is evaluated at US$22.7 million. No information was available on the unavoidable damages to the infrastructure and other assets.

# *Macroeconomic impact assessment*

Based on known damage and losses at the time of publication, overall impacts to the economy are not expected to be significant at the national level.

Overall, agriculture, forestry, and fishing comprise approximately 9-12% of the national GDP. However, the share of oblast-level agricultural production in national GDP is likely to be quite low[42]. In the four oblasts of concern, the estimated 306,500 hectares of cropland now lacking irrigation represents approximately 4% of the total land cultivated in 2020[43]. Before the war, this area comprised a small percentage of the overall national production[44,45]. Overall, the relatively small contributions of the affected irrigated areas to the national economy combined with the recent suppression of agricultural activities due to the war, suggest that, under the as-

42. https://unfao.sharepoint.com/:x:/s/OER/EUlvFQ2DpsRCkEyN4wCQp-8ButGj1o4VYxe7MYj9oWWB9A
42. World Bank. 2021. Ukraine: Building Climate Resilience in Agriculture and Forestry. 2021. © World Bank.
43. State Statistics Service of Ukraine, 2020
44. https://fews.net/europe-and-eurasia/ukraine/key-message-update/june-2023
45. https://www.bbc.com/news/world-europe-65963403

sumption of normal rainfall, the anticipated decreased yields due to lack of irrigation are not expected to have a significant short-term impact on the national economy.

However, a lack of sufficient rain could aggravate the economic impact for as long as the irrigation systems remain non-functional. A FAO geospatial assessment has already identified that more than 9,000 ha of irrigated cropland is demonstrating water stress conditions just a few weeks after the dam burst. Global climate change as well as potential micro-climate changes induced by the draining of the reservoir render rainfalls increasingly uncertain. Projections of climate change and its effect on agriculture have identified that the south and southeast region will generally become drier and hotter and will show the highest decrease in precipitation during summer months[46].

Neither the relatively small extent of direct flooding on cropland in Ukrainian-controlled areas nor the limited damage and loss to the livestock sector are expected to noticeably impact the overall agricultural sector in Ukraine in the near future.

Given that fishery activities were already halted in the affected area, the short-term economic impact specifically attributable to the dam burst is negligible. However, the near-complete loss of the reservoir, river, and delta, will likely significantly impact the fishery sector as well as aquaculture activities that rely on the proximity to these water sources in the long term.

## *Human Impact Assessment*

Nationally, about 72 percent of rural households are involved in agriculture. Due to the war, rural farming households reported declines in income due to a reduction in their agricultural activity and increases in production costs. Total damages and losses in the first six months of the war comprised more than US$2 billion for the crops and livestock sectors[47].

A recent study found that rural households in oblasts classified as front-line areas tended to have less diverse income sources (56% report zero or one income source) and were more reliant on aid from government or humanitarian organizations (exceeding 50% in Zaporizhzhia and Mykolaiv). These point to higher vulnerability and lower resilience to economic shocks for rural farming households[48].

The locations of households that are most at risk for food insecurity and determined to be most vulnerable overlap with three of the four affected oblasts (the fourth, Kherson, could not be accessed at the time of the assessment). Households living within 30 km of the front-line were also more likely to be vulnerable because of not being able to fulfill their essential needs.[49]

Against this context of already diminished income, lower resilience, and increased vulnerability, the destruction of the Kakhovka dam is likely to have a significant and long-term impact on the livelihoods of the affected population including the loss of some 21,000 agriculture-related jobs. Crop producers who experienced flooding of their land will lose all production while those dependent on irrigation will likely face a harvest with reduced yields, both for the current season and likely for many years to come. Fisherfolk have been completely devastated by the loss of the reservoir and face an indefinite pause on their ability to pursue their livelihood. Beyond the producers, those employed in salaried positions in state-owned irrigation and aquaculture enterprises are also facing sudden job loss.

The affected areas may also be at an elevated risk for food insecurity. Reductions in household incomes combined with an anticipated decrease in harvests, damage to small plots for household subsistence farming, and lack of local fish catch, may lead to fluctuations in local food prices, food availability, and household-level dietary diversity.

47. World Bank. 2021. Ukraine: Building Climate Resilience in Agriculture and Forestry. 2021. © World Bank.

47. AO. 2022. Ukraine: Impact of the war on agriculture and rural livelihoods in Ukraine – Findings of a nation-wide rural household survey, December 2022. Rome. https://doi.org/10.4060/cc3311en

48. FAO. 2022. Ukraine: Impact of the war on agriculture and rural livelihoods in Ukraine – Findings of a nation-wide rural household survey, December 2022. Rome. https://doi.org/10.4060/cc3311en

49. WFP 2023. Ukraine Needs Assessment: Food Security and Essential Needs

## Reconstruction and Recovery Needs, including Build Back Better

**For the agricultural sector to recover and to support agricultural livelihoods in the affected areas** the following measures need to be taken in different time frames. The estimated agriculture sector needs amount to US$180 million over 10 years.

1. Provide access to agricultural inputs or finance / voucher distributions to farmers with flooded land to re-establish their lost crop and livestock production and to assist fishers whose livelihoods have been affected;
2. Support crop farmers engaged in vegetable production as they reduce their dependance on surface irrigation, by establishing new water sources, introducing drip irrigation for high value crops/ perennial crops, solar irrigation, small- and large-scale rainwater harvesting, etc.
3. Help livestock farmers find alternative solutions for accessing livestock drinking water (rainwater harvesting, alternative surface sources, water treatment, wells, and boreholes). Restore flood damaged irrigation infrastructure, including pumping stations (modernization, construction, reconstruction and/or overhaul of the current irrigation system networks); procurement of and training in using rainwater harvesting systems, and gray water reuse systems, particularly for rural households and small farms.
4. Re-establish supply chain links of fingerlings, fry, and aquaculture supplies and ease market disruptions for aquaculture producers. Given the loss of three large operators, support will be needed to strengthen the links and to reorient part of the production towards fry and fingerlings to supply the commercial farms.
5. Provide training to farmers in all impacted lands to transition to conservation/regenerative agriculture techniques that improve soil quality, retain water, and have been demonstrated scientifically to help almost all crops produce better under low water regimes.
6. De-risk investment options and find innovative tools to attract investment in the short term. As financial liquidity impacts the vast majority of agricultural crop, livestock, and fish producers and fisherfolk, a systematic and sustainable approach to facilitating access to finance to the affected producers is a significant element to be addressed on the way to recovery. This could possibly be addressed through online investment platforms, matching grants, or better links between financial institutions and producers.
7. Establish a comprehensive agriculture-related water, soil, and crop/ fish monitoring programme and rehabilitation program to protect human health and to ensure the markets and livelihoods of producers downstream from the dam collapse. Early indications suggest toxic contamination of fields and water sources, which are likely to further impact the markets for producers in the affected oblasts for years to come.
8. Support the government and IT partners to improve agricultural digitization; this is a request of the government but can also help respond to the Kakhovka dam and other conflict-related disasters by better tracking farmers' needs, understanding where environmental risks are present, linking suppliers to the markets that need them, and reducing food loss and waste.

**The principal recovery and reconstruction focus for the first year includes these measures:**

Table 20: Recovery and reconstruction needs (USD million) as of July 30, 2023

Source: Assessment team

| Category | Component | Immediate/ short term | Medium- to long-term | Total |
|---|---|---|---|---|
| **Reconstruction Needs** | 1. Restoration of livelihoods of flood affected smallholders, including HHs and small crop farmers and fishermen through provision of access to agricultural inputs or finance | 3.50 | 3.00 | 6.50 |
| | 2. Introduction of irrigation alternatives among crop farmers and alternative drinking water for livestock among livestock producers | 21.50 | 43.00 | 64.50 |
| | 3. Irrigation channels and pumping stations affected by floods | 8.00 | 4.00 | 12.00 |

| Category | Component | Immediate/ short term | Medium- to long- term | Total |
|---|---|---|---|---|
| **Reconstruction Needs** | 4. Recovery of aquaculture production and culture-based fisheries | 5.50 | | 5.50 |
| **Service Delivery Restoration Needs** | 5. Technical Assistance to address changing cropping patterns and to address potential desertification | 11.00 | 15.00 | 26.00 |
| | 6. Agricultural financing for crop farmers, livestock and fish farm producers and capture fishers | 15.00 | 35.50 | 50.50 |
| | 7. Monitoring programme for toxic and radioactive substances in agriculture-related water, cropland soil and food products | 2.00 | 5.00 | 7.00 |
| | 8.Improved agricultural digitalization | 3.00 | 5.00 | 8.00 |
| **Total** | | **69.50** | **110.50** | **180.00** |

## *Notes on the Methodology including Assumptions and Limitations*

### Methodology

The FAO Agriculture Damage and Loss methodology[50] was used as the basis to understand the impact of the dam collapse on the crop, livestock, fishery, and aquaculture sectors. The methodology was adjusted and extended to account for the complexity of the sector participants and contexts and the types of effects on the production. On the basis of the methodology, sectorial assignments with questions and data needs were developed for assessment of each type of damage and loss indicator.

The data for each question was collected using remote sensing, statistical information, and feedback from central and local self-government sources.

On the basis of the collected data, values for the standard damage and loss indicators were extrapolated and applied to the calculation of damages and losses (e.g., share of loss of fish population). In parallel, asset valuations (e.g., replacement values of assets, average yields, and gross production value per unit etc.) were established based on literature reviews and statistics.

The values of the damage and loss indicators were correlated in multiplication frames to the national statistical data, for development of the overall impact indicators on affected area level (e.g., total quantity of fish lost). As a final step, the values from the asset valuations were added to the multiplication frames to produce the overall damage and loss valuations (e.g., total livestock lost at the average value per unit).

### Limitations

- A short time frame for the assessment, combined with an urgent humanitarian situation in hard-hit areas, priorities related to the ongoing war, confidentiality of data, and lack of ability to visit the field resulted in limited data availability. Significant data gaps, in particular on damage, has resulted in considerable underestimations in this assessment across all sub-sectors.
- Though care was taken to avoid conflating damage from the conflict and damage specifically from the dam burst, this was challenging due to a lack of baseline information from immediately before the disaster.
- Aside from data obtained through remote sensing, there is a near complete lack of information available from occupied territory.

50. See: https://www.fao.org/3/ca6990en/CA6990EN.pdf

# Commerce and Industry

## Summary

**The Kakhovka Dam breach resulted in damages of US$7.4 million to the Commerce and Industry[51] sector.** 65% of the damage affected industry, particularly small private firms, and the remainder impacted commerce in the flood-affected Kherson region downstream of the dam. Satellite imagery confirmed infrastructure damages, including flooded buildings and disrupted utilities.

**The total industrial and commercial losses due to the Kakhovka dam breach are estimated at US$77.0 million for 18 months.** The breakdown includes US$70.7 million for industry and US$6.3 million for commerce, reflecting decreased business activity in 2022, and considers both flooding and water deficit in Kherson and Dnipro regions.

The Kakhovka dam burst had a localized impact on commerce and industry, especially on the vital shipbuilding sector in Kherson and Mykolaiv. Existing challenges from the war were exacerbated. The preservation of this sector is crucial to the economy, education, and research. Metallurgy, another significant export-oriented industry, is concentrated in Dnipropetrovsk, Zaporizhzhia, and Donetsk regions; their importance has increased due to the destruction in Donetsk region, and water and energy security are essential to prevent economic disruption.

**Total reconstruction and recovery needs for the commerce and industry sector are US$20.0 million.** This sum includes US$11.0 million for industry, US$9.0 million for commerce, US$13.0 million for physical facilities (65% of total needs), and US$7.0 million for service restoration, including demolition and debris removal.

## Context

The PDNA for Kakhovka dam burst for the Commerce and Industry sector focuses on Kherson, Dnipropetrovsk and Zaporizhzhia regions as the most directly affected (such as flooding in Kherson region) and indirectly impacted (water deficits in Dnipropetrovsk and Zaporizhzhia regions). This chapter considers the damage caused to the production assets of enterprises and losses associated with declines in their business activities. Environmental aspects are covered in a separate chapter of the report.

According to the State Statistics Service, in 2020, 17,688 industrial enterprises (including 10,194 business entities) were present in Dnipropetrovsk, Kherson, and Zaporizhzhia regions, providing jobs for 470,000 people and generating approximately US$25.2 billion in revenue. Dnipropetrovsk and Zaporizhzhia regions are much more industrialised than Kherson and most other regions of Ukraine, with large enterprises in the metallurgical, metal processing, and chemical sectors. As for the trade sector of these regions, in 2020, it employed 386,000 people and had a turnover of US$22.0 billion (with the major share generated in the Dnipropetrovsk region).

The ongoing war has caused significant damage to commerce and industry in Zaporizhzhia (US$526 million according to the RDNA 2) and Kherson regions (US$18.7 million), while the damage to Dnipropetrovsk region was not reported. Losses in the sector have been caused by decreasing markets, increasing costs, lack of availability of supplies, disrupted trade routes and supply chains, and displaced customers, further reducing local markets. Losses due to the ongoing war were estimated at US$3,721.1 million for the Zaporizhzhia region, US$255.0 million for the Dnipropetrovsk region, and US$213.2 million for the Kherson region.

Despite the declined economic activity of enterprises in these regions, the relatively small area of damage from the dam burst (compared to the total area impacted by hostilities) and the lack of data for the non-government controlled areas (on the left bank of the Dnipro), the isolated impact of the Kakhovka dam burst still has a significant impact on commerce and industry in Kherson and Dnipropetrovsk regions.

51. The Commerce and Industry sector excludes ports and energy infrastructure, which are included in other parts of the Post Damage and Needs Assessment (PDNA), and it does not provide estimates for subsectors due to the lack of data.

## Damage and Loss Assessment

**The total damage to the industry and commerce facilities due to the Kakhovka Dam breach is estimated at US$7.4 million.** Most of the damage (65 percent) was to industry (small private companies), with the remaining to commerce. All the damage was incurred by enterprises located downstream of the Kakhovka dam (in the Kherson region) because of the flooding. Damage caused by possible accidents at industrial facilities due to the unexpected interruption of water supply was not reported. Therefore, the damage to industry and commerce is assumed to be localised only to the flooded area, which was identified using satellite images. Thus, the damage included ruined infrastructure (flooded premises, communications, in particular, electricity supply grid), destroyed and drowned equipment, and spoilt and swept away products. For commerce, the main damage relates to warehouses located in the flooded area.

There are 50 flooded enterprises that belong to industry, construction, business services, or commerce. Sectoral distribution is diverse, with 38 unique codes of economic activity. The largest companies are shipbuilders, agricultural machinery/equipment dealers, and manufacturers of metal products. These companies provided jobs for up to 1,000 locals.

| Category | Total value (US$ million) | Share of total (%) |
|---|---|---|
| **Commerce, including:** | **2.6** | **35.2** |
| Shops | 0.1 | 1.4 |
| Warehouses | 2.5 | 33.8 |
| Gas stations | - | - |
| Pharmacies | - | - |
| Shopping center according to the ICSC classification | - | - |
| **Industry, including:** | **4.8** | **64.8** |
| Large and medium-sized private enterprises | - | 0 |
| Small private enterprises | 4.8 | 64.8 |
| State enterprises | - | 0 |
| **Total** | **7.4** | **100.0** |

**Table 21:** Damage by category (US$ million) as of July 30, 2023

Source: Assessment team

The total industrial and commercial losses due to the Kakhovka dam breach are estimated at US$77.0 million for an 18-month period. Losses for industry and commerce were calculated based on data from the latest available financial reports, which reflect the already decreased business activity of companies in the region in 2022. Total losses are about US$70.7 million for industry and about US$6.3 million for commerce. These identified losses include companies affected by flooding in Kherson Region as well as companies affected by the water deficit in the Dnipropetrovsk region.

It is worth noting that industry and commerce in the Dnipropetrovsk region have demonstrated remarkable resilience to the impact of the Kakhovka Dam burst. Thus, in response to the water shortage, industrial enterprises used alternative water supply options by commissioning artesian wells or extending water intake routes (in particular, by building new channels to the Dnipro reservoir). Commercial companies switched to water that was trucked in and reduced their water consumption. This allowed the companies to keep their operations going even during the first month after the breach when the water shortage was the most severe. However, companies from the sector still suffered a decrease in revenues.

The parts of Zaporizhzhia region controlled by the Ukrainian government, and the city of Zaporizhzhia in particular, are mainly supplied with water not from Kakhovka but from the Dnipro reservoir, which is separated by the dam of the Dnipro hydroelectric power plant in Zaporizhzhia. Therefore, enterprises in the Zaporizhzhia region were least exposed, as they faced relatively few

problems with water and energy supply. Data on companies from non-government-controlled areas (NGCA) of the Zaporizhzhia region on the left bank of the Dnipro River is not available. Those companies have probably already reduced their economic activity independently of the dam burst.

**Table 22:** Losses by category (US$ million) as of July 30, 2023

Source: Assessment team.

| Category | Total value | Share of total (%) |
|---|---|---|
| **Commerce, including** | **6.3** | **8.2** |
| Unearned income from commerce | 6.3 | 8.2 |
| Demolition and Debris removal | - | - |
| **Industry, including** | **70.7** | **91.8** |
| Decrease in income of large and medium-sized private enterprises | 67.7 | 87.9 |
| Decrease in income of small private enterprises | 3.0 | 3.9 |
| Decrease in income of state-owned enterprises | **-** | **-** |
| Decrease in income of certain industries | - | - |
| Demolition and Debris removal | - | - |
| Total | 77.0 | 100.0 |

**The total cost of the dam burst for industry and commerce is estimated at US$84.4 million, with losses accounting for 91 percent of the total** (Table 23).

**Table 23:** Damage and losses by oblast (US$ million) as of July 30, 2023

Source: Assessment team.

| Oblast | Damage | Losses | Total Costs | Share of total (%) |
|---|---|---|---|---|
| Dnipropetrovsk | - | 67.7 | 67.7 | 80 |
| Kherson | 7.4 | 9.3 | 16.7 | 20 |
| Mykolaiv | - | - | - | - |
| Zaporizhzhia | - | - | - | - |
| **Total** | **7.4** | **77.0** | **84.4** | **100.0** |

In the case of industry and commerce, the impact of the Kakhovka dam burst is rather localised, particularly in areas that have been actively devastated since 2022 due to the hostilities. It is, therefore, difficult to separate the effects of this accident. The flooded areas were not as industrialised, except for the shipbuilding sector. However, the latter de facto stopped production in 2022, as manufacturing facilities were captured, and shipping was impossible during the war. For Kherson and Mykolaiv (as well as for the national economy), shipbuilding was an important, dynamically developing industry with high added value, which also accumulated and enhanced local expertise (including sectoral educational and scientific institutions). Therefore, preserving this sector during the war and its recovery will be critical.

For Ukraine, iron ores, products, and ferroalloys were among the main exported industrial products. Metallurgy was mainly concentrated in Dnipropetrovsk, Zaporizhzhia, and Donetsk regions. Considering the total destruction of industry in the non-government-controlled areas of the Donetsk region (including Mariupol), now Dnipropetrovsk and Zaporizhzhia regions are the main producers of items critical to the reconstruction. It is worth noting that in 2021, metallurgy by itself provided more than 66,000 jobs in the Dnipropetrovsk region and

28,000 in the Zaporizhzhia region, while related mining and quarrying provided additional 77,000 jobs. Despite the quite resilient response of the main enterprises in the industry to the water shortage caused by the destruction of the Kakhovka dam and the continuation of operations with some temporary reduction in production while alternative water sources have been identified and commissioned, there is still a risk to their continuous operation, especially in case of the destruction of the Dnipro dam. It is important to ensure their water and energy security, as the shutdown of these enterprises would have a dramatic impact on the national economy and the incomes of the local population.

## Reconstruction and Recovery Needs, including Build Back Better

**Total reconstruction and recovery needs for the commerce and industry sector are US$20.0 million, of which US$11.0 million relates to industry and US$9.0 million to commerce.** Reconstruction needs for physical facilities and productive assets (considering build back better approach) are estimated at US$13.0 million (Table 24) or 65 percent of the estimated total needs. Recovery needs to restore service delivery are US$7.0 million. Needs for demolition and debris removal are included in the calculation.

While the damage incurred to commerce and industry in the region as a result of the dam burst may appear relatively small, we must take into account (i) the compound effects of the damages incurred by the ongoing war and the damages resulting from the dam burst; (ii) the relatively concentrated nature of the damage meaning that, while large areas of the region remain relatively unaffected, certain communities are greatly impacted as a result; (iii) the linkages between commerce/industry and other, more impacted productive sectors in the region, such as agriculture, which may have longer term consequences for the recovery of commerce and industry.

| Category | Component | Immediate/ short term | Medium- to long-term | Total |
|---|---|---|---|---|
| Reconstruction Needs | Physical facilities and productive assets | 6.5 | 6.5 | 13.0 |
| Service Delivery Restoration Needs | Support for the production recovery | 3.5 | 3.5 | 7.0 |
| **Total** | | **10.0** | **10.0** | **20.0** |

**Table 24:** Recovery and reconstruction needs (US$ million) as of July 30, 2023

Source: Assessment team. Following RDNA, total needs are split evenly between short and medium terms.

## Key Recommendations to revitalize and restart Commerce and Industry and allied sectors, including Build Back Better

For the commerce and industry sector to recover from the dam burst, support overall economic recovery in the region, and serve as a decent income source for inhabitants of the region, the following measures need to be taken:

- prioritize support to businesses (SMEs) in the Kherson region that were directly impacted by the dam breach (due to flooding) and impacted businesses providing essential goods and services for the communities they serve.
- introduce supporting mechanisms for the restoration of businesses in affected areas, including providing financial support to businesses in the form of grants, matching grants, and low-interest loans (considering the size of a company) to support reconstruction, repair, replacement of damaged assets and construction of new auxiliary facilities to keep operations running (like water supply and water treatment facilities).
- encourage investment in greener, renewable, and resource-efficient (including energy-efficient) construction and productive assets as part of the reconstruction as well as the digitalization of businesses as a key to improved productivity and accessing new market opportunities.
- promote green recovery of industrial zones using the modern eco-industrial parks model, which fos-

ters cross-industry and community collaboration for common benefits related to economic, social, and environmental performance.

- assess the linkages between damages to industry and commerce in the region and other productive sectors and provide technical support for recovery to businesses that contribute to the growth of and/or rely on other sectors (such as agriculture).
- re-build key logistics infrastructure within communities required to facilitate trade and access to markets.
- incentivise the development of business capacity (with a focus on MSMEs) to respond to emergencies, including regular on-site training, and to minimize environmental damage from technogenic accidents with a possible expansion beyond the currently affected areas.
- initiate improving water and energy security of businesses and communities, in particular in terms of sourcing, supply, distribution, and responsible consumption.
- empower individuals to participate in the region's sustainable economic recovery by establishing capacity building programs for those among the affected population, including reskilling in green industry-related skills.
- promote the employment of disabled individuals by fostering accessible workplaces, providing support to enterprises in adapting their facilities, offering training opportunities tailored to the needs of disabled individuals, and working to reduce bias and stereotypes surrounding disabilities.
- introduce an electronic system of registration of damage (not only environmental) and losses for transparent reporting and accounting to assist central and local authorities, as well as donors, in addressing these issues.

## *Notes on the Methodology, including Assumptions and Limitations*

Damage and loss calculation is based on financial reports of companies registered in respective locations (including territories not controlled by the Ukrainian Government). Financial reports are available online as a part of the public open data portal. For most companies, it was possible to identify the flooding status using satellite imagery provided by the EMITTER project, which is realized under the financial support of the European Union. Only assets classified as "possible flooding" or worse were included.

For damages, relevant articles are undepreciated fixed assets, unfinished capital investments, and inventories. In calculation, it is assumed that all the assets are destroyed (even in case of partially damaged), as it will better reflect real damage to them considering the level of their depreciation.

To separate general invasion effects and dam destruction, the figures as of the end of 2022 were used. For losses, the revenues for 2022 were used. We assume that a company in the region discontinues its business activities completely.

For other regions, we estimated revenue decrease based on public statements of companies that reported significant effects. ArcelorMittal Kryvyi Rih was the largest of them; it reported a decrease in steel production in May by 50%.

Needs are calculated as a sum of reconstruction needs and recovery needs. Following World Bank's RDNA 2, the coefficient for BBB (build back better) for asset reconstruction was set to 1.75 for industry and 1.5 for commerce. Needs for recovery are the sum of additional expenses and working capital needed to restore activities. The latter is calculated as pre-invasion annual sales (for 2021) multiplied by 0.35.

Needs calculations were based on available data and may be underestimated. For example, there could be assets that belong to companies that are registered in other regions. The incentive mechanisms described in the recommendations are not currently included in the needs.

# INFRASTRUCTURE SECTORS

# Municipal Services and Community Infrastructure

## Summary

**The total damage to the Municipal Services and Community Infrastructure sector is estimated at US$127.8 million.** The extent of municipal damage is spread mainly across only two regions: Kherson and Mykolaiv oblasts. Holoprystanska, Oleshkivska, and Novokahovska are Kherson oblast's most flood-affected territorial communities. In the Mykolaiv region, Snigurivska, Horohivska, and Shyrokivska territorial communities were affected due to increased water levels in the Ingulets River. The flooding impacted municipal assets, units, spaces, buildings, and facilities. Most of the affected areas and most of the damages in the Kherson region are on the left bank of the Dnipro River. **Losses in the sector are estimated at US$6.2 million, mainly from costs of debris removal and losses of revenue of waste management entities.** According to IOM data, nearly one-third of the pre-2022 population left the affected regions due to hostilities, primarily families and working-age individuals. The dam's destruction further displaced many. Consequently, most of the remaining population in these communities are elderly, pre-retirement, or disabled. Damage to administrative buildings hinders local governance. The absence of essential municipal services discourages the return of young families. The remaining residents rely more on state services, but their limited mobility and digital literacy necessitate accessible services nearby.

**The recovery and reconstruction needs for Municipal Services and Community Infrastructure are estimated at US$292.6 million, including US$87.8 million for immediate recovery.** Addressing municipal sector recovery needs requires a strategic approach at the local level, restoring services using an integrated approach based on the Building Back Better principle (digital services, mobile centers for administrative services, etc.) that delivers resilient, sustainable, and efficient recovery solutions to affected communities. Damage to local community enterprise assets not only restricted services to the public but also impacted businesses subcontracted by local authorities for recreation and waste disposal services. Local budget revenues and service capabilities are strained as these businesses relocate or halt operations. Therefore, restoring services and rebuilding community infrastructure is crucial for recovery.

## Context

According to RDNA 2, the war has not only resulted in damage to communal infrastructure and gaps in service delivery but has also strained the capacity of local governments. Already prior to the war, service provision was irregular, and coverage rates were low, particularly for waste management. As of February 24, 2023, the war is estimated to have caused the largest damages to the municipal infrastructure and services sector in Kherson, Zaporizhzhia, and Mykolaiv oblasts (US$239 million, US$2171 million, and US$156 million in damages, respectively) and in Dnipropetrovsk (US$38 million). The report states that the role of local governments in recovery and reconstruction is vital and goes beyond just municipal assets, with local authorities being critical for the implementation, coordination, and planning of measures stipulated by individual functional sectors and line ministries.

## Disaster Effect

Early 6th June, the Kakhovka dam (Kherson Oblast) was breached, allowing water to surge and flood downstream areas. On 7 June, satellite imagery showed that around 820 km2 were underwater[52]. The breach resulted in mass flooding, impacting an estimated 46 settlements across both the right and left banks of the Dnipro. The State Emergency Service of Ukraine (SESU) has reported that the dam break affected four regions: Kherson, Mykolaiv, Dnipropetrovsk, and Zaporizhzhia.

Data on municipal services and community infrastructure are accessible for the right bank of the Dnipro River. Ukrainian authorities indicate that the situation is concerning on the Russian-occupied left bank of the Dnipro River, which has also been heavily affected by the flood (please see Box 1 below).

The number of IDPs in the aftermath of the dam destruction is estimated to be about 3,000 persons[53] and

52. DG ECHO ERCC Analytical Brief, Kakhovka dam break, DG ECHO and JRC, 16 June 2023
53. IOM, Nova Kakhovka Dam Flooding, Rapid Needs Assessment, Update 2, 16 June 2023

mostly residing in the Kherson oblast itself, with some ending up in Dnipropetrovsk and Mykolaiv oblasts[54]. The majority of IDPs remaining in neighboring locations indicate a strong intention to remain close to their homes and return as soon as possible due to fear of looting and loss of other productive assets.

## *Damage and Loss Assessment*

The flooding impacted municipal assets, units, spaces, buildings, and facilities. Municipal services were disrupted, in particular:

1) disrupted services on solid waste management (this sector includes such assets as containers for household waste collection, Trucks for garbage collection, container sites, sorting lines, landfills, and biogas plants);

2) disrupted access to public spaces and public facilities (e.g., public squares, urban parks, gardens, outdoor green and recreational areas, cemeteries, libraries, and recreation centers);

3) disrupted access to administrative buildings (e.g., local government administrative buildings and offices, local government administrative service centers and spaces);

4) disrupted services on local mobility (e.g., sidewalks, streetlights);

5) disrupted access to sports facilities (e.g., stadiums, swimming pools, sports schools, sports halls, ice rinks).

Local authorities were not able to provide local people with administrative services (such as issuance of permits/licenses, certificates, certificates, registration, etc.) due to damage to administrative buildings. Affected cities/communities have no or limited access to municipal public services, including housing and communal services, household services of the population, access to local public spaces etc.

54. The number excludes population in the NGCA

### Damage to municipal property

| Category | Total value (US$ million) | Share of total (%) |
|---|---|---|
| Solid waste management | 5.65 | 4.40 |
| Public spaces and public facilities | 78.18 | 61.20 |
| Administrative buildings | 18.05 | 14.10 |
| Local mobility | 11.98 | 9.40 |
| Sports facilities | 13.96 | 10.90 |
| **Total** | **127.82** | **100.00** |

**Table 25:** Damage by asset type (US$ million) as of July 30, 2023

Source: Assessment team.

### The losses due to the Dam Breach

| Category | Total value (US$ million) | Share of total (%) |
|---|---|---|
| Costs of rubble/ debris removal | 5.00 | 80.00 |
| Local government estimated revenue Losses | n/a | n/a |
| Increase in operational costs and expenditures incurred by local governments | n/a | n/a |
| Loss of revenue of waste management entities | 1.21 | 20.00 |
| **Total** | **6.21** | **100.00** |

**Table 26:** Losses by category (US$ million) as of July 30, 2023

Source: Assessment team.

The total cost of the dam breach for the Ukrainian municipal services sector is estimated at US$134.03 million, with losses accounting for 4.6% percent of the total.

**Table 27:** Damage and losses by oblast (US$ million) as of July 30, 2023

Source: Assessment team.

| Oblast | Damage | Losses | Total Costs | Share of total (%) |
|---|---|---|---|---|
| Kherson | 125.74 | 5.38 | 131.12 | 97.80 |
| Mykolaiv | 2.08 | 0.83 | 2.91 | 2.20 |
| Dnipropetrovsk | n/a | n/a | n/a | n/a |
| Zaporizhzhia | n/a | n/a | n/a | n/a |
| **Total** | **127.82** | **6.21** | **134.03** | **100.00** |

### ***Box 1.*** *The situation on the left bank of the Dnipro River: Hola Prystan' town is an example of damage to municipal infrastructure in a city located in the NGCA (based on data from key informants)*

Almost all communal infrastructure has been flooded or destroyed in the town; there has been the uncontrolled burial of animals and people; and a rapid accumulation of solid household waste. The flooding destroyed a large part of the housing stock, causing a significant decrease in the population. For example, until February 24, 2022, the population of Hola Prystan' (administrative center of Hola Prystan' Territorial Community) was about 14,000, and as of July 2023, no more than 3,000. Local budget revenues are closely linked with small and medium businesses that used to operate in the community. Therefore, local economic development will largely depend on the scale of return of the population that left the place.

The flooding had done significant damage to municipal property:

- **Solid waste management:** 120 containers were damaged. Out of 17 container warehouses (multi-story buildings), only one site was not flooded. Debris from damaged infrastructure and housing is accumulating and not being removed.
- **Public places and public facilities:** Over 25 hectares of urban parks, gardens, and open green and recreational areas have been flooded.
- **Cemeteries:** Several rural cemeteries have been flooded—two in Kardashynka (1.0 and 0.6 hectares), two in Kokhany (0.6 ha), one in Mala Kardashynka (2.1 ha), and three in Velyka Kardashynka (3.3 ha). While the town's cemetery (14.5 ha) has not been flooded, it needs demining.
- **Libraries:** Of 12 libraries, 6 have been flooded, one of them completely destroyed.
- **Administrative buildings and offices of local self-government bodies:** 32 buildings of local self-government bodies have been flooded and partially damaged.
- **Local mobility:** about 60,000 square meters of sidewalks were damaged, and over 1,200 street light points need to be restored.
- **Sports facilities:** Velyka Kardashynka Stadium, Hola Prystan' City Stadium, Mala Kardashynka Stadium, the Town Palace of Sports and Physical Health, and "Sports for All" premises have all been flooded.

## Economic Impact Assessment

Damage to the assets of local community enterprises limited the provision of services to the population. It also affected businesses, which were subcontracted by local authorities to provide some of the recreation and waste disposal services. As local businesses relocate or suspend operations, local budget revenues and service provision capabilities come under stress.

## Human Impact Assessment

According to key informants and IOM data, about a third of the pre-2022 population left the communities of the affected regions due to migration caused by hostilities, mostly families with children and people of working age. The destruction of the dam also led to the displacement of the work-age population with children. As a result, a significant share of the population living in the affected communities consists of pre-retirement and elderly people and people with disabilities. Damage to administrative buildings complicates or makes impossible the effective operation of local self-government bodies. The lack of key municipal services—such as recreation and administrative services —is a significant barrier to initiating the return of young people and families with children. The remaining population tends to have higher reliance on the state for social and administrative services, but due to its low mobility and lower digital literacy, may require such services to be provided near their homes and in an accessible manner.

The following outcomes are likely:

- Increase in non-monetary poverty, as local communities are deprived of key services undermining the quality of life along with basic services such as education, health, and housing.
- Limited access and lower quality of service provision, e.g., domestic waste being not processed and having to travel to nearby locations to receive administrative services
- Business suspension and relocation as administrative services are not provided or local procurement is being disrupted

## Reconstruction and Recovery Needs, including Build Back Better

For the Municipal Services and Community Infrastructure sector to recover and serve the residents of the affected areas, the estimated needs amount to US$292.6 million over ten years. The needs estimated for 2023-2026 are US$87.78 million, or about 30 percent of the total needs (Table 28).

| Category | Component | Immediate/ Short-term Needs 2023-2026 | Medium- to Long-term Needs 2027 -2033 | Total Needs 2023-2033 |
|---|---|---|---|---|
| Reconstruction Needs | Reconstruction of assets | 47.77 | 160.12 | 207.89 |
| | Technical works including planning, assessments and studies and enhancements in institutional and implementation processes | 12.25 | 8.44 | 20.69 |
| | Debris processing and disposal | 1.25 | 0.25 | 1.50 |

**Table 28:** Recovery and reconstruction needs (US$ million) as of July 30, 2023

Source: Assessment team.

| | | | | |
|---|---|---|---|---|
| Service Delivery Restoration Needs | Upkeep of services and increased service delivery in IDP hubs | 2.65 | 1.80 | 4.45 |
| | Repair, and stabilization of prioritized public and service delivery infrastructure | 13.65 | 22.16 | 35.81 |
| | Coordinated and efficient debris removal and waste management | 2.25 | 1.25 | 3.50 |
| | Operational costs - goods, equipment and infrastructure | 7.95 | 10.80 | 18.76 |
| **Total** | | **87.78** | **204.82** | **292.60** |

## The municipal sector needs by category

In the short to medium term, the following activities should be undertaken to ensure municipal sector recovery:

**Solid waste management.** The introduction of separate waste sorting and the construction of biogas plants will have a positive economic effect on the community by reducing land pollution due to the flooding of waste collection and disposal sites and widespread practice of illegal waste disposal before the flooding.

**Public spaces and facilities.** It is important to conduct a thorough assessment of the needs of the affected communities and to develop local recovery action plans for the restoration of the relevant facilities. It will be important to restore recreation areas in cities, which will be an important pull factor for displaced families with children and youth. It will also have a positive economic effect in the long run, as recreation and tourism accounted for a significant share of local budget revenues before the war and flooding.

**Administrative buildings.** To ensure administrative service provision, it would be necessary to restore the assets (premises, communications, equipment, and facilities) of damaged administrative buildings and service centers. Part of the solution to the problem can be the digitization of services, the provision of services using mobile devices, as well as the creation of a network of new modular Administrative Service Centers, in which uniform standards for the quality of services provision will be introduced. The new formats provide for the provision of services in separate front and back offices, equipped with the necessary equipment and furniture, the creation of open space in the service area, comfortable places for waiting and service, including for persons with disabilities, online registration for visiting the center, and universal service by high-level specialists.

**Local mobility.** An adequate level of public mobility, safety, and comfort is a prerequisite for the return of community residents. One of the solutions could be the creation of a modern video surveillance system in the community to ensure public order, safe road zones in the proximity to social institutions; updating pedestrian crossings, road markings, and their lighting at night; improving the organization of road safety (carrying out works on laying sidewalks, footpaths, etc.). Street lighting is one of the main elements of urban development, as it ensures safety for pedestrians.

**Sports facilities.** At the initial stage, it will be important to conduct damage assessments, emergency measures for sports facilities, stabilization and conservation measures for damaged assets, storage management, and immediate conservation to prevent further damage.

### *Box 2: Marine and River Transport Infrastructure*

The "green deal" aspect of Ukraine's Euro-integration agenda involves a partial shift in transportation logistics away from roads and towards waterway transportation. This requires restoring navigation on the Dnipro River, which relies on functioning shipping locks on the Dnipro cascade. The reconstruction and modernization of the Kakhovka Lock are vital steps in ensuring uninterrupted ship passage, crucial for post-war reconstruction efforts. The initial estimated costs for this endeavor are approximately US$200 million.

Furthermore, water transport infrastructure in Kherson oblast, including berths and passenger piers, as well as state-owned passenger vessels under the "Administration of River Ports" have been either damaged or lost. Infrastructure, including vessels, at the Port of Kherson and the Kherson River port, and the Adziogol Lighthouse under the jurisdiction of the state agency Derzhgidrografia have also sustained damages.

Source: Managing Authority of Sea and River Transport (Mininfrastructury)

## *Key Recommendations for municipal services and community infrastructure recovery*

**Recovery and to Build Back Better:**

- Repair, reconstruction, and stabilization of prioritized municipal assets based on the critical local needs assessment;
- Establishing an online municipal recovery market (platform) to search local enterprises which supply relevant services for recovery (e.g. Handwerk-baut-auf in Germany);
- Setting up production and/or logistics chains for the supply of building materials, lumber, glass, metal-plastic windows and doors, and consumables for the installation of building structures.
- Decentralized participatory planning and resource mobilization:
- Local detailed municipal recovery strategy/action plans (based on needs assessment, forecasted trends of local development, and taking into account the Build Back Better principle) are critical for resource mobilization for the most affected towns/communities.

**Economic activity:**

- Support to local MSME business recovery and development;
- Provision of utility companies with machinery and equipment and backup power supply;
- Creation of conditions for MSMEs by restoring the supply of critical local services (water supply, gas, electricity, heat supply);
- Creation of space for conducting business on the basis of communal property (co-working spaces, spaces for production, provision of services to consumers, etc.).

**Service delivery:**

- Maintaining a proper level of service delivery;
- Identifying new approaches for service delivery (digital administrative services, mobile centers for administrative services);
- Identifying critical service delivery bottlenecks:
- Increase service coverage with a focus on the most vulnerable;
- Undertake repairs of partially damaged service delivery infrastructure and critical facilities.

**Strengthening human capital:** For the development of human capital, the community needs to ensure the observance of human rights to a dignified life in the community, create conditions for the return of community residents, improve the quality of life by providing as wide a range of municipal services as possible, restore and modernize cultural institutions, first of all, libraries

by transforming them into accessible interactive children's libraries spaces, youth spaces, creation of clubs based on interests, social spaces, etc. on their basis.

**Capacity building:** Ensuring maintenance of services through increasing operational capacity (personnel, goods, technology, and equipment).

**Monitoring/Data collection:**

- Using modern tools to understand the profile of the population.
- Data on the number and status of locally maintained and owned assets should be aggregated and documented regularly at the local level. The municipal monitoring system would allow identifying municipal infrastructure needs and gaps for better recovery of service delivery.

## *Notes on the methodology, including assumptions and limitations*

For the purpose of this assessment, the municipal infrastructure and services cover five categories of assets:

1) Solid waste management;
2) Public spaces and public facilities;
3) Administrative buildings;
4) Local Mobility assets;
5) Sports facilities.

Within each asset category, asset types included do not cover the exhaustive set because of data limitations, but they do reflect the diverse range of infrastructure and services that fall under the remit of local governments. For this assessment, experts used baseline data and data on unit costs and damage provided in RDNA 1 and 2. The damage and losses are, therefore, to a large extent, analysed based on information from multiple sources. In preparation for this section, the Assessment Team organized a data collection process based on RDNA methodology. The Assessment Team carried out an analysis of official data of the Ministry for Communities, Territories and Infrastructure Development of Ukraine (letter # 11259/25/10-23 from 16.07.2023), feedback from community focal points, ground surveys (questionnaire on assessment of municipal services), social media analytics and data from partners, donors, and the public domain. Findings used to estimate the levels of damage caused by the flooding include both banks of the Dnipro River. However, the quality of data for the left bank is relatively poor, and the information is likely incomplete. The estimated numbers are indicative.

# Energy

## *Summary*

Preliminary estimates place the damage to the energy infrastructure in the Kherson oblast at US$1.26 billion, chiefly from the irreparable destruction of the Kakhovka Hydroelectric Power Plant (HPP), accounting for US$1.2 billion. This devastation led to flooding, predominantly impacting the power distribution system infrastructure in Kherson oblast, valued at US$44 million. There's potential underestimation due to limited data from regions not under government control. Flooding also affected the oil and gas sector, causing a loss of 17 fuel stations and two oil depots with around US$12 million in damages. While the impact on the gas network seems minor, damages to gas regulation points and the district heating sector are about US$4 million. The energy sector's overall losses from the dam explosion surpass US$3.8 billion, with Ukrhydroenergo's revenue losses from the Kakhovka HPP destruction at US$96 million (with the estimated US$138 million revenue losses due

to the unsold electricity and ancillary services based on annual average values). Debris removal and salvaging might cost an extra US$86 million, likely to increase upon a detailed site survey. The Kakhovka Reservoir was critical for the cooling systems of the Zaporizhzhia Nuclear Power Plant (ZNPP), Ukraine's largest nuclear power plant. The dam breach and drainage of the reservoir put the operation of the ZNPP at risk. This implies major revenue losses for the state-owned power plant operator Energoatom, estimated at over $US3.6 billion.

The energy sector's total reconstruction and recovery needs are estimated at nearly US$1.8 billion, with approximately US$439 million allocated for the immediate response in 2023-2024. These immediate needs aim to restore power, which is critical for reconstruction and recovery efforts. In the short term, the power sector will require US$61 million. The gas distribution infrastructure also has specific essential equipment needs in the short term. To reinstate the district heating infrastructure in controlled territories, an investment of US$6 million is necessary, particularly for pumps, control cabinets, and other related items, to prepare for the upcoming heating season. Moreover, potential damages might necessitate an additional US$25 million for repairs to the 11 central heating units and the four boilers affected by flooding. The ZNPP faces challenges in ensuring a stable cooling water supply during the dam's 6-year restoration period but currently utilizes existing water ponds and has a backup from an alternate water source and newly drilled bore wells. To maintain safety, it's crucial to follow the IAEA's recommendations, including ensuring stable backup power and exploring non-water-intensive cooling methods like the proposed Dry Air-cooling system, estimated to cost US$14 million.

## *Context*

Since February 2022, the aggression drastically altered the energy sector in Ukraine. Over the recent months, Ukraine's energy infrastructure has been subjected to numerous missile and drone attacks, artillery shelling, and cyberattacks on energy companies, causing significant harm and damage to the integrated energy system, including power generation and transmission infrastructure. The damage and loss incurred by the energy sector in Ukraine have been quantified in a report prepared by UNDP in May 2023. However, the situation escalated dramatically in June 2023, when the Kakhovka dam was destroyed.

The energy sector of Kherson and Zaporizhzhia oblasts in Ukraine was directly affected by the Kakhovka dam explosion, significantly impacting their power generation capacities. Prior to this devastating event and the full-scale war, both regions were vital contributors to the country's electricity production. Before the full-scale invasion, both Kherson and Zaporizhzhia oblasts contributed significantly to Ukraine's power generation capacities (23% of total power generation capacities as of the end of 2021)[55]. The Kakhovka HPP (Hydro Power Plant) and RES (Renewable Energy Systems) installations provided a notable portion of the Kherson region's electricity needs. Prior to the invasion, annual electricity production in the region corresponded to over 300% of its power demand. Meanwhile, Zaporizhzhia Oblast, with its major nuclear power generation and RES capacities, played a crucial role in supplying a significant portion (over 26%) of the country's electricity.

The Kakhovka HPP has an installed generating capacity of 343 MW[56]. Additionally, small- and medium-scale RES played a significant role, with solar generation accounting for 500 MW, wind generation at 583 MW, and two biogas stations at 4 MW[57]. Notably, in 2021, the Kakhovka HPP produced 1.1 TWh of electricity, while other RES supplied 1.88 TWh, contributing nearly 2% to Ukraine's overall electricity supply[58]. According to available data, Kherson Oblast is the only oblast where the dam explosion damaged the energy infrastructure.

Zaporizhzhia Oblast also contributed significantly to Ukraine's electricity supply. The Zaporizhzhia Nuclear Power Plant (ZNPP), temporarily controlled by the Russian Armed Forces[59], played a prominent role, generating a staggering 36 TWh, equivalent to a quarter of the country's total electricity demand. The Zaporizhzhia Thermal Power Plant (ZTPP), also temporarily controlled by the Russian Armed Forces, added to the region's capabilities with 2850 MW, while the Dnipro Hydro Power

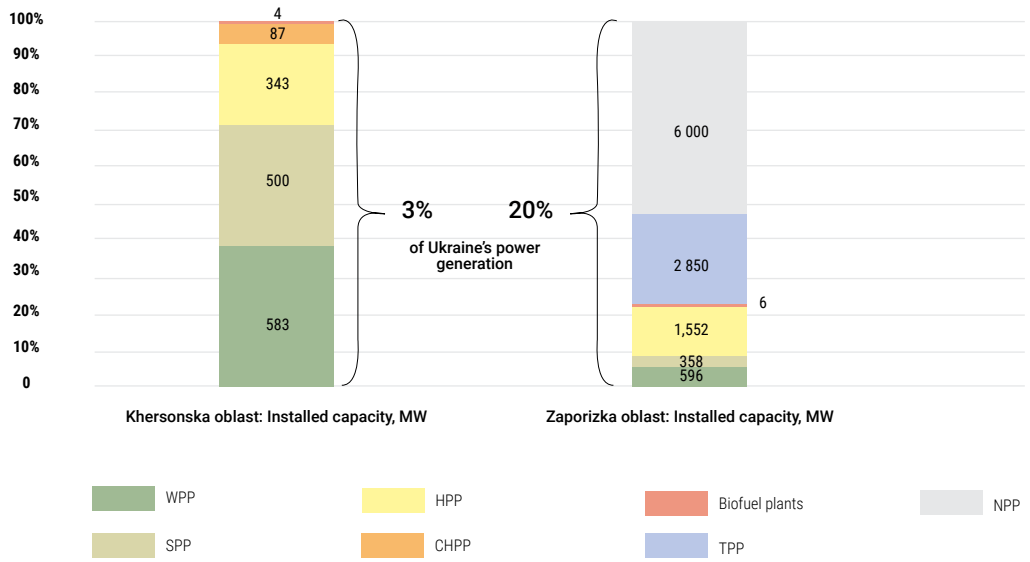
55. NEC «Ukrenergo» data on installed power generation capacities.
56. PJSC «Ukrhydroenergo».
57. NEC «Ukrenergo» and energy companies' data on installed power generation capacities by type of generation and RES capacities by oblast.
58. The National Commission for State Regulation of Energy and Public Utilities (NEURC).
59. The International Atomic Energy Agency (IAEA). 2022. Nuclear Safety, Security and Safeguards in Ukraine.

https://www.iaea.org/sites/default/files/22/09/ukraine-2ndsummaryreport_sept2022.pdf

Plant contributed an additional 1563 MW[60]. Renewable energy also played a crucial role in Zaporizhzhia Oblast's power generation portfolio, reaching over 960 MW[61].

In addition to the effects mentioned above, it should be noted that the destruction of the Kakhovka Dam caused not only the loss of the overall electricity generation capacity in the country, but also the loss of highly maneuverable peak-load generation capacity on the HPP in the amount of 340 MW. The temporarily occupied Zaporizhzhia Thermal Power Plant, with the installed capacity of 2850 MW and annual generation of 4.5 TWh, has lost its source of water for turbine condenser cooling. Besides, the destruction of the Kakhovka Dam brought on the loss of additional water supply for the cooling pond of the Kryvyi Rih TPP, causing the reduction of its generation capacity by 600 MW.

**Figure 10:** Power generation capacities of the regions affected, Dec 2021
Source: Ukrenergo statistical data




## Damage and Loss Assessment

**Current damage to energy infrastructure is estimated at US$1.26 billion and is fully attributed to the Kherson Oblast.** According to the JSC Ukrhydroenergo[62] that administers major hydro power plants in Ukraine, including Kakhovka HPP), the destruction of the Kakhovka HPP makes it irrecoverable, constituting the bulk of the damage—around US$1.2 billion. The dam destruction resulted in a flood, directly damaging energy assets in the Kherson Oblast. This includes the power distribution system infrastructure (US$44 million), with several distribution-level substations, underground and overhead cable lines. The lack of data in this category, due to the large portion of the area affected temporarily not being under government control, is likely to make the estimates less than what they should be[63].

**Oil and gas sector:** Flooding has resulted in the loss of at least 17 fuel stations and two oil depots. These assets' damage estimates are around US$12 million. Based on the limited information available, the impact on the gas network is minor compared to other subsectors. The damage to several gas regulation points and the district heating system is estimated at US$4 million[64].

61. NEC «Ukrenergo» and energy companies' data on installed power generation capacities by type of generation.
62. NEC «Ukrenergo» data on RES capacities by oblast.
62. JSC Ukrhydroenergo is a joint stock company, whose stock is 100% government-owned.
63. Assets located in territories temporarily not under government control are estimated to be partially damaged based on the flooding estimates. There is a possibility that more territories and consequently assets were damages in these areas. The ability to verify the damage is absent at this point.
64. If there is a direct impact on the 11 central heating units and four boilers, damage to the district heating sector could potentially go up by US$25 million (including assets in territories temporarily not under government control), depending upon the level of damage to the boilers and the heating units.

**Estimated losses related to the dam explosion in the energy sector exceed US$3.8 billion[65].** The largest share of loss is attributed to the revenue lost by two major state-owned energy companies of Ukraine – Energoatom and JSC Ukrhydroenergo, the latter losing US$96 million worth of revenue because of the Kakhovka HPP destruction. The estimated revenue losses of Ukrhydroenergo due to the loss of electricity and ancillary services sales amounted to US$138 million (annual average based). Removing debris and salvaging the powerplant may cost an additional US$86 million. This estimate is likely to go up after carrying out a detailed survey of the explosion site.

The Kakhovka Reservoir, created by the dam, was critical to maintaining the water level to fill the cooling water pond and spray ponds for Nuclear Reactors and the spent fuel storage at the Zaporizhzhia NPP, Europe's largest nuclear power plant. With the dam breach and the consequent drainage of the reservoir, the pond is not being filled properly, endangering the cooling of the six reactors that have been shut down and the spent fuel storage[66]. This poses a threat to nuclear safety. To enable the NPP to produce electricity on an industrial scale, either the dam should be rebuilt, or an effective alternative found to restore the supply of water to the plant. This implies major revenue losses for the state-owned nuclear power plant operator Energoatom estimated at over US$3.6 billion.

Table 29: Damage and loss, by subsector (US$ million)

| Category | US$ million |
|---|---|
| **Damage:** | **1,260** |
| Power Generation (Kakhovka HPP) | 1,200 |
| Power Distribution | 44 |
| Oil and Gas | 12 |
| District Heating | 4 |
| **Loss:** | **3,811** |
| Power Generation. Zaporizhzhia NPP | 3,629 |
| Power Generation. Kakhovka HPP[67] | 182 |
| **Total Damage and Loss** | **5,071** |

## *Reconstruction and Recovery Needs, Including Build Back Better*

**In the aftermath of the dam explosion, maintaining a balance between short-term energy needs and long-term development and transition goals proves challenging amid the high uncertainty resulting from the ongoing war.** Most areas where energy infrastructure was affected by the flooding are temporarily occupied by Russian forces. Fast recovery hinges on the top priority of restoring energy and utility services, ensuring the basic needs of people living in the affected territories, and facilitating the return of internally displaced persons (IDPs). However, the situation in the NGCA raises additional concerns due to the lack of information and the potentially wider affected areas. Currently, ensuring and monitoring the provision of basic needs for people in these territories is impossible. On the other hand, decisions made during the post-war reconstruction period will have far-reaching consequences, impacting not only economic recovery but also energy security priorities and the country's green transition objectives.

The post-war context presents a unique opportunity to reevaluate energy sector priorities, with a specific focus on building more flexible, RES power generation and creating an efficient power distribution network to

66. The losses were estimated by comparing the level of production and wholesale electricity prices in 2019-2022, taking into account the production decreases caused by the dam explosion, and dismantling costs for the destructed HPP.
67. IAEA Director General Statement on Situation in Ukraine. June 21, 2023.
https://www.iaea.org/newscenter/pressreleases/update-167-iaea-director-general-statement-on-situation-in-ukraine
67. This figure includes the US$96 million direct revenue loss of Ukrhydroenergo plus the US$86 million for debris removal.

minimize losses and enhance overall energy resilience. To "build back better," Ukraine should emphasize green transitions, prioritizing renewable energy sources and sustainable practices. As large-scale reconstruction takes place across all sectors, public and private, including households, incorporating green technologies, and reducing dependency on fossil fuels[68], while ensuring independence from the grid is at the forefront of energy policy considerations. Careful planning and systematic implementation of the best practices with laws and regulations for Feed in Tariffs for the pro-users (user and exporter of power such as household/public school solar producers and exporters) will be key to ensuring sustainable and feasible investments in green initiatives, attracting financing from various institutional, public, and private sources. As the nation moves towards recovery, seizing this moment to transform the energy landscape can lead to a more sustainable, secure, and prosperous future for Ukraine.

**The total reconstruction and recovery needs in the energy sector are estimated at US$1.8 billion, including US$439 million for the immediate response (2023-2024).** The immediate short-term needs are required to restore the power to provide critical support for reconstruction and recovery. The short-term recovery needs in the power sector (US$61 million) encompass power cables (35 kV, 10 kV, 0.4 kV – 57 km in total), transformers for substations (150, 35/6 kV, 10/0.4 kV, 6/0.4 kV – over 150 units in total), 0.4 kV circuit breakers (990 units in total), fuses (10 kV, 0.4 kV – 960 units in total), discharges (10 kV, 6 kV – 300 units in total), vacuum switches (35 kV, 10 kV – 18 units in total), cable couplings (35 kV, 10 kV, 0.4 kV – 420 units in total), as well as cabinets and relay protection panels (35 kV, 10kV – 18 units in total) for substations[69]. For the gas distribution infrastructure, specialized on-board manipulator equipment, specialized excavator equipment, cabinet gas regulating points, combined home pressure regulators, mobile compressor station, repair kits of gas regulation equipment, and sets of filter elements of the gas regulation point are particularly essential in the short-term. Meanwhile, to restore the district heating infrastructure in the GCA (US$6 million), pumps, pump control cabinets, electrical panels, and switchboards are needed. This will help to concentrate the immediate focus on the preparation for the next heating season. Another US$25 million may be required depending on the damage to the 11 central heating units and the four boilers due to flooding.

It is crucial to note that the equipment mentioned above pertains solely to areas under the Government of Ukraine's control. At present, detailed short-term energy needs of the population in territories temporarily not under government control cannot be estimated. Further, funds are required to address losses in the sector's short-term operations. This includes the need to close liquidity gaps (US$373 million) in the power generation sector, particularly key state-owned electricity producers JSC Ukrhydroenergo and Energoatom.

**Nuclear safety must be addressed in the short- and medium-term perspectives.** To avert emergency situations and mitigate any risks of nuclear danger, it is imperative to adhere to the recommendations of the IAEA. These recommendations include: (i) Prohibiting the placement of military equipment at the nuclear facility and refraining from using the station for military purposes; (ii) Ensuring stable back up power lines (currently one 750 kV and one 330 kV) electricity supply lines to meet the station's needs; (iii) Ensuring the safe operation of the cooling pond while also exploring alternative methods to ensure the cooling of reactors and spent nuclear fuel. By adhering to these guidelines, the integrity and security of the Zaporizhzhia Nuclear Power Plant can be proactively safeguarded during the dam's restoration period [70] [71].

The restoration of the dam may take over 6 years. The short-term critical need of cooling water is being met with the existing inventory in the cooling water ponds and as well as spray water ponds adjacent to the site. Currently the ZNPP has a supplementary source of cooling water—from a rivulet. Deep bore-wells are also being drilled to ensure there is a backup for emergencies. Back-up for auxiliary power was being met initially with a 750 kV line. However, now it has a 330 kV line for additional backup. It's obvious that making sure ZNPP operates safely would involve the demilitarization of the Nuclear Plant.

While rebuilding of the dam is an option to meet the water demand of the ZNPP, the IAEA has explored another option for medium to long term consideration—a Dry Air-cooling system that is not water intensive. Implementing this would take time, and the estimated cost is around US$14 million.

**To finance the long-term goals in the reconstruction process,** especially for the state-owned power generation companies Energoatom and the JSC Ukrhydroenergo[72], Ukraine must prioritize policies that minimize fiscal liabilities in the sector, stimulate external financing, and improve transparency and internal implementation capacity. The cost of reconstruction of the destructed Kakhovka HPP would depend on the capacity of the site as well as the results of the examination of its de-

68. Ukraine is a net-importer of most of the fossil fuels used for energy supply.

69. The detailed list of equipment needed for the DSOs is presented in the Annex 2.

70. IAEA. 2022. Nuclear Safety, Security and Safeguards in Ukraine. 2nd Summary Report by the Director General. https://www.iaea.org/sites/default/files/22/09/ukraine-2ndsummaryreport_sept2022.pdf

71. IAEA Director General Statement on Situation in Ukraine. June 16, 2023. https://www.iaea.org/newscenter/pressreleases/update-166-iaea-director-general-statement-on-situation-in-ukraine

72. Article 62 of the Electricity Market Law of Ukraine governs the imposition of public service obligations (PSO), as special obligations on market participants (including Ukrhydroenergo and Energoatom) for ensuring the supply of electricity to households at regulated tariffs.

bris, but preliminary analysis shows it may cost nearly US$1.2 billion of which the medium-term investment requirement would be US$400 million.

Ukraine is taking strides towards the development of RES in its legislative framework. The Ukrainian Parliament has enacted a law regarding the "Restoration and Green Transformation of the Energy System of Ukraine" No. 9011-d. This law's implementation holds the potential to achieve several important objectives:

(i) Allow the completion of construction of RES facilities that were frozen due to full-scale aggression by the end of the current year while preserving the "pre-war" conditions of support;

(ii) Enable the reconstruction of damaged or out of order RES power plants while maintaining previously obtained conditions of support;

(iii) Introduce guarantees of origin to the Ukrainian market;

(iv) Revamping green auctions and introducing new mechanisms of state support and market interactions for RES producers (Net Billing mechanism for self-production contracts, contracts for the difference, opportunity of market electricity sales for feed-in premium holders saving the ability to get back to the support mechanism).

**Long-term goal of the Ukraine's energy sector** is to transition from the current energy mix of fossil fuel (primarily coal) and aging inefficient gas-based central heating systems to more efficient and sustainable technologies across the regions and various sectors. A planned phased approach is required to decarbonize and implement upgraded energy-efficient systems across the power generation, transmission, and distribution system. This would involve full realigning of the state and national laws for generation, transmission, and distribution with the EU laws.

The Ukraine government should thoroughly explore options for the transformation of the power sector in the affected regions and alternatives that align with national commitments to green transition and recovery plans. Moreover, future decisions regarding development and long-term reconstruction should be responsive to the social and economic context of the regions in the post-war period, which will shape the demand in the energy market. By considering these factors, Ukraine can effectively navigate the complexities of funding and policy implementation, ensuring a sustainable and successful energy sector recovery and transition[73].

The Ukrainian government and the market are best placed to determine the most suitable replacement for the destroyed Kakhovka HPP. Various alternative solutions exist to replace the lost power capacities, such as other RES like solar, wind, or biogas-fired facilities. However, it's important to consider the characteristics of each option. Solar and wind energy are intermittent sources of electricity and might require additional investments in energy storage installations to match the flexibility of the hydropower facility. On the other hand, biogas power plants could serve as a viable substitute and may involve the participation of more market players. The capital costs for these projects depend significantly on their scale, transmission infrastructure, and other factors. As of 2021, International Renewable Energy Agency (IRENA) estimates that the global capacity-weighted average total installed cost of utility-scale PV projects stood at US$857/kW, while onshore wind projects averaged US$1,325/kW, and biogas-fired plants, US$4,593/kW[74].

**The Water & Sanitation (WSS) sector sustained phys-**

73. Energy strategy of Ukraine for the period of 2050, which was approved by the Cabinet of Ministers on 21.04.2023 #373-p

74. IRENA (2022), Renewable Power Generation Costs in 2021, International Renewable Energy Agency, Abu Dhabi. https://www.irena.org/publications/2022/Jul/Renewable-Power-Generation-Costs-in-2021

| Category | Types of activities/investments | Short-term (2023-2024) | Medium-term (2023-2027) | Long-term (2027-2033) | Total (2023-2033) |
|---|---|---|---|---|---|
| **Reconstruction needs** | Power sector reconstruction, including power generation capacities and distribution system operator infrastructure | 61.4 | 400.0 | 800.5 | 1,261.9 |
| | District heating reconstruction, including heating points and heat-only boiler houses | 5.5 | | | 5.5 |

**Table 30:** Recovery and reconstruction needs (US$ million) as of July 2023

Source: Assessment team.

| Category | Types of activities/investments | Short-term (2023-2024) | Medium-term (2023-2027) | Long-term (2027-2033) | Total (2023-2033) |
|---|---|---|---|---|---|
| **Reconstruction needs** | Oil and Gas sector reconstruction, including restoration of flooded facilities of gas distribution operators, oil depot and gas stations | | 16.4 | | 16.4 |
| **Service delivery restoration needs** | **Power sector liquidity needs** | 372.5 | | | 372.5 |
| | **Kakhovka HPP dismantling costs** | | 85.8 | | 85.8 |
| **Nuclear safety measures** | **Cost of backup dry air-cooling systems for ZNPP** | | 14.0 | | 14.0 |
| **Total** | | **439.4** | **516.1** | **800.5** | **1,756.0** |

# Water and Sanitation

## *Summary*

**ical damages estimated at US$65.92 million.** Of this, approximately US$39 million pertains to the destruction of water and sanitation infrastructure. Significant damages, accounting for 40% (US$27 million) of the total costs, affected machinery, equipment, and essential service components, hindering the effective operation of water and sanitation services. **Losses, which are changes in economic flows arising from the disaster, have been estimated at US$82.82 million.** After the breach of the Kakhovka dam, the WSS sector envisaged substantial losses not only due to the disruption of water and sanitation services and the decline of operational revenues but also to extra costs required to ensure the safety of the provided water and sanitation facilities.

**The WSS sector requires US$700.93 million as recovery and reconstruction costs[75] to address the needs of downstream flooded areas and upstream areas with water shortages.** The assessment is split between short-term (US$336.91 million) and medium- to long-term (US$364.01 million) expenditures, which allows for prioritization of the investment efforts and preparation of the sector for the required infrastructure development.

According to Ukraine Rapid Damage and Needs Assess-

## *Background & Context*

ment[76], before the war, access to centralized piped water supply in Ukraine was estimated at 70 percent, and access to centralized wastewater collection and treatment services at around 50 percent[77]. Approximately 10 million people lacked access to safely managed water services and 20 million lacked access to centralized wastewater collection and treatment services. There are significant inequalities between urban and rural

76. The Government of Ukraine's approach to restoring water supply and sanitation services considers, when applicable, implementing new infrastructural projects rather than reconstructing existing damaged and outdated facilities. New projects are designed with increased capacities, modernized technologies, and decentralized service provision. Most existing and abandoned facilities are not considered "damaged"; thus, their cost is not included in the damages and losses assessment.

76. Ukraine Rapid Damage and Needs Assessment. The World Bank, EU and UN. February 2022 – February 2023

77. Government of Ukraine. National report on the quality of drinking water and the state of drinking water supply in Ukraine for 2020.

areas in piped water access (80 percent in urban areas versus 34 percent in rural areas), flush toilet access (86 percent versus 26 percent), and sewer connections (75 percent versus just 8 percent).

Ukraine's water and sanitation infrastructure, mainly built in the 1960-70s, is a heavily centralized system that provides services to urban and rural settlements across vast areas of the country and, in many cases, crosses through several oblasts. Due to a lack of capital investment over the years (only 8 percent of the WSS sector budget is allocated to capital investments), outdated infrastructure and equipment compounded with the ongoing war, and inadequate Operation and Maintenance (O&M) expenditure, the WSS sector requires considerable investments to rebuild. Meanwhile, operational revenue in the WSS sector declined sharply due to reduced water consumption.

The breach of the Kakhovka dam released over 18 cubic km of water in a 4-day period, posing significant threat in 80 settlements in four oblasts—Kherson, Mykolaiv, Dnipropetrovsk, and Zaporizhzhia, directly affecting 100,000 residents. Upstream settlements were also affected due to the non-functionality of the reservoir, which resulted in up to one million people facing disruption in drinking water provision and sanitation services.

## *Damage and Loss Assessment*

### Damage to infrastructure and assets

The estimated aggregate physical damage for the WSS sector stands at **US$65.92 million** (Table 31); of this amount, around US$39 million is the cost of total/partial destruction of water and sanitation infrastructure. Noticeable damage (US$27 million, or about 40 percent of the overall cost of damaged assets) was also inflicted upon machinery, equipment, trucks, pumps, spare parts, treatment chemicals, and reagents.

Most of the infrastructure damage consists of the destruction of large installations like sewage pumping stations, water supply and sewage collection networks, and drinking water treatment plants and facilities. A number of shallow and deep wells and septic tanks, which are critical for the functioning of WSS systems, have been damaged as well, but utilities are constantly working to fix those to ensure the provision of basic WSS services.

Losses, which are changes in economic flows arising

| Cost of destruction of infrastructure and assets | Total value (US$ million) | Share of total (%) |
|---|---|---|
| Water distribution networks | 1.61 | 2.44 |
| Water treatment plants and filtration stations | 3.15 | 4.78 |
| Water pumping and boosting stations | 2.22 | 3.37 |
| Wells (artesian, and other hydrogeological) | 0.90 | 1.37 |
| Water reservoirs | 1.50 | 2.28 |
| Sewage pipelines | 1.05 | 1.59 |
| Wastewater treatment plants and pumping stations | 3.96 | 6.01 |
| Septic tanks | 0.85 | 1.29 |
| Drainage systems | 2.25 | 3.41 |
| Solid waste treatment facilities | 0.85 | 1.29 |
| Machinery and equipment | 12.27 | 18.61 |

**Table 31:** Damages by asset type (US$ million) as of July 30, 2023

Source: Assessment team.

* Damages in NGCA are estimated at 100% of the damages in GCA

| Cost of destruction of infrastructure and assets | Total value (US$ million) | Share of total (%) |
|---|---|---|
| **Cost of damage to other assets** | | |
| Administrative buildings, laboratories, warehouses | 1.00 | 1.52 |
| Spare parts, treatment chemicals and reagents | 1.35 | 2.05 |
| **Sub-total for GCA** | **32.96** | **50.00** |
| **Sub-total for NGCA*** | **32.96** | **50.00** |
| **Total Damages** | **65.92** | **100.00** |

## Losses due to the dam breach

from the disaster, have been estimated at **US$82.82 million** (Table 2). After the breach of the Kakhovka dam, the WSS sector estimated substantial losses not only due to the disruption of water and sanitation services and decline of operational revenues but also to extra expenses required to ensure the safety of the provided water and sanitation facilities. This includes disinfecting and flushing the systems, cleaning blocked septic tanks, sewers, and drains, and conducting additional water quality testing before resuming supply.

Almost 22 percent of the total losses are from the decline in operational revenues. The war significantly reduced water consumption as millions fled the country, and many industries temporarily closed or significantly reduced their water usage.

The rest of the economic losses are due to increases in operational costs associated with the provision of temporary water, sanitation, and solid waste management services, increased prices of materials and equipment, lack of required repairs, tariff deficits, water losses, increased costs for chemical reagents, and necessary demolition and debris removal.

**Table 32:** Losses by category (US$ million) as of July 30, 2023

Source: Assessment team

* Assumption that losses in NCGA are at 50% of GCA losses

| Category | Total value (US$ million) | Share of total (%) |
|---|---|---|
| Cost of provision of temporary water | 23.05 | 27.83 |
| Cost of cleaning of blocked systems | 1.75 | 2.11 |
| Cost of disinfection and flushing the systems | 0.49 | 0.59 |
| Increase in operational costs | 6.80 | 8.21 |
| Decline in operational revenues | 11.77 | 14.21 |
| Disruption to water and sanitation services | 7.95 | 9.60 |
| Demolition of damaged assets and removal of debris | 1.90 | 2.29 |
| Water quality testing (additional) | 0.25 | 0.30 |
| Water contamination and water-borne diseases | 1.25 | 1.51 |
| **Sub-total for GCA** | **55.21** | **66.67** |
| **Sub-total for NGCA*** | **27.61** | **33.33** |
| **Total Losses** | **82.82** | **100.00** |

**Disruption to water and sanitation services**

The Kakhovka reservoir played a crucial role in providing energy, drinking water, irrigation, and river transport to various regions in southern Ukraine, as well as supplying water for industries in the main cities of Dnipropetrovsk, Mykolayiv, Kherson oblasts. The dam breach disrupted water supply and sanitation services in government-controlled areas in four oblasts (Dnipropetrovsk, Zaporizhzhia, Mykolayiv, Kherson), causing losses of **US$7.95 million**, giving rise to unsanitary and unhealthy conditions, impeding service delivery, and causing structural damage to water and sanitation systems.

**Possible risks due to disruption of water services**

Living in conflict areas with frequent disruption of water and sanitation services, combined with limited access to public health services, led to increases in waterborne diseases. Ensuring health and well-being of the affected populations by addressing risks of contamination of water sources and water-borne diseases is another critical component of the sectoral losses estimated at **US$1.5 million**[78].

## Disaster Effects

The total cost of disaster effects from the dam breach for Ukrainian Water Supply and Sanitation sector is estimated at US$148.74 million, with losses accounting for about 56 percent of the total disaster effects.

Table 33 shows damages and losses by the affected oblasts. Kherson and Mykolaiv suffered both damages and losses due to flooding. Although there was no direct damage due to dam breach in Dnipropetrovsk and Zaporizhzhia oblasts, the latter suffered losses due to water supply shortages.

| Oblasts | Damages (US$ million) | Losses (US$ million) | Total Effect (US$ million) | Share of Total (%) |
|---|---|---|---|---|
| Dnipropetrovsk | 0.00 | 10.66 | 10.66 | 7.17 |
| Kherson | 19.92 | 19.66 | 39.58 | 26.61 |
| Mykolaiv | 13.04 | 16.89 | 29.93 | 20.12 |
| Zaporizhzhia | 0.00 | 8.00 | 8.00 | 5.38 |
| **Sub-total for GCA** | **32.96** | **55.21** | **88.17** | **59.28** |
| **Sub-total for NGCA** | **32.96** | **27.61** | **60.57** | **40.72** |
| **Total** | **65.92** | **82.82** | **148.74** | **100.00** |

**Table 33:** Damage and losses by oblast (US$ million) as of July 30, 2023

Source: Assessment team.

## *Macro- and Micro-economic Impacts:*

The economic impacts of damage and loss in the WSS sector include increase in living cost due to increase in cost of water; decrease in production sector due to limited availability of water; temporary decline in employment; and loss of income.

## *Human Impacts:*

The human impacts include limited access to drinking water and sanitation services; increased cost of water; increase in water-borne diseases; food insecurity and increase in malnutrition of children; and migration and displacement.

78. Water quality testing during provision of temporary water is included in the estimate

## Reconstruction and Recovery Needs

Reconstruction and Recovery needs were assessed with respect to the following two categories:

1. Infrastructure reconstruction needs;
2. Service delivery restoration needs;

The WSS sector requires US$700.93 million for recovery and reconstruction (Table 4) to address the needs of downstream flooded areas and upstream areas with water shortages. The assessment is split between short-term and medium- to long-term expenditures, which allows for prioritization of the investment efforts and preparation of the sector for the required infrastructure development.

Short-term needs include projects in the GCA committed by the Government of Ukraine and development partners and include several new water supply projects in Kryvyi Rih, Marganets, Pokrov, Nikopol, Zaporizhzhia, and Tokmakivka. Several reconstruction and rehabilitation projects are also included in the recovery needs. The NGCA's recovery needs are included in the medium- to long-term investment plan.

The reconstruction and recovery needs include i) construction of new facilities and ii) restoration of the damaged WSS infrastructure. Both components adopt the Build Back Better approach, applying new capacity requirements, materials, and technologies.

**Table 34:** Recovery and reconstruction needs (US$ million) as of July 30, 2023

Source: Assessment team.

| Category | Description | Short-term (US$ million) | Medium- to Long-term (US$ million) | Total (US$ million) | Share of Total (%) |
|---|---|---|---|---|---|
| **Reconstruction Needs** | Restoration of water infrastructure | 262.00 | 30.38 | 292.38 | 41.71 |
| | Restoration of sewer infrastructure | 40.14 | 17.72 | 57.86 | 8.25 |
| | Restoration of drainage infrastructure | 8.51 | 5.00 | 13.51 | 1.93 |
| | Restoration of solid waste management facilities | 5.35 | 2.75 | 8.10 | 1.16 |
| **Service Delivery Restoration Needs** | Replacement of machinery and equipment | 11.92 | 0.35 | 12.27 | 1.75 |
| | Replacement of spare parts, treatment chemicals and reagents | 1.00 | 0.45 | 1.45 | 0.21 |
| | Provision of temporary water and sanitation services | 2.90 | 6.83 | 9.73 | 1.39 |
| | Restoration of administrative buildings, laboratories and warehouses | 0.95 | 0.14 | 1.09 | 0.16 |
| | Disinfection, flushing and cleaning of blocked systems | 2.24 | 0.00 | 2.24 | 0.32 |
| | Demolition of damaged assets and debris removal | 1.90 | 0.00 | 1.90 | 0.27 |
| | Sub-total for GCA | **336.91** | **63.62** | **400.53** | **57.14** |
| | Sub-total for NGCA | | **300.40** | **300.40** | **42.86** |
| | Total Recovery Needs | **336.91** | **364.01** | **700.93** | **100.00** |

## Key Recommendations to Restore the Water Supply and Sanitation Sector

a) Investments to restore water and sanitation services in four affected oblasts (US$700.93 million) after the Kakhovka dam breach should be added to the nationwide recovery and reconstruction cost of Ukraine's water and sanitation infrastructure, which entails investments of around US$7.15 billion[79];

b) Considering the required large-scale sectoral investments, the reconstruction efforts should be combined with institutional strengthening and capacity building to ensure sustainable operation and maintenance of the newly developed infrastructure;

c) Sector reforms will be needed to deliver the ambitious medium- to long-term plan for the WSS, which entails investing around US$643 million;

d) Due to the ongoing war and the WSS sector's limited investment experience, technical support and coordination are required to address large WSS needs;

e) Contingency planning should be strengthened to ensure that water utility companies continue to have the capability for timely restoration of essential WASH services;

## Notes on the Methodology, including Assumptions and Limitations

The sector analysis is based on the data sourced from the Government of Ukraine, Regional Military Administrations, the WASH Cluster, local Water Authorities, and development partners. Based on available data, the scope of the assessment was decided, and further detailed data analysis was conducted. This was followed by meetings with the respective authorized stakeholders, who, in most cases, were the custodians of the data received.

Key limitations faced in this WSS sector assessment include:

- Data collection templates were not strictly followed by all government agencies nor well understood, so the data quality varied, and a large part of the assessment had to be based on assumptions.
- Due to ongoing war, there was a general lack of data on asset inventories, baselines for infrastructure, and service levels. This limited options to undertake deeper analysis.
- Data for Non-Government Controlled Areas are unavailable and based on assumptions.
- With no centralized source for information on community infrastructure, all information had to be based on secondary data.

79. Ukraine Rapid Damage and Needs Assessment. The World Bank, EU and UN. February 2022 – February 2023

# CROSSCUTTING SECTORS

# Environment

## Summary

The Kakhovka hydroelectric dam breach caused a catastrophic flood, affecting 620 km² of land and altering river morphology, causing chemical pollution, habitat destruction, and potential long-term environmental impact. Sediment transport led to a sediment plume in the Black Sea, causing high turbidity and affecting nearshore activities for months. Around 192 hazardous facilities were identified, with 54 as potential hotspots, releasing approximately 150 tons of machine oil alongside concerns of contamination from pesticides and fertilizers. Downstream surface water pollution was noted, with increased biological oxygen demand (BOD) and organic matter in the Black Sea, potentially affecting aquatic life and water quality. The disaster also impacted 330,00 ha of protected areas and 11294 ha of forested areas. Following Government-approved methodology, the Ministry of Environmental Protection and Natural Resources of Ukraine has calculated the damages[80] to natural resources as approximately US$4.36 billion[81]. Due to the limited access to the areas damaged by the flooding, validating the damages included in these calculations has been impossible. However, the PDNA estimates over US$6.4 billion in ecosystem service losses (58% of all losses) due to the impact on protected areas and forests.

**Reconstruction and recovery needs in the environment sector total US$59.5 million, with priorities including de-mining, cleanup, surveys, and contaminated site assessments.** Recovery efforts in the forestry sector require extensive activities that span from short to long-term. Initially, the impacted area must be de-mined, necessitating adequate personnel training. Short-term rehabilitation includes clearing the terrain, harvesting affected biomass, preparing soils, and replanting with robust, sustainable saplings. Integral to this process are capacity building, infrastructure development like roads and nurseries, equipment procurement, and covering transportation costs.

Additionally, remnants of war equipment must be removed long-term. It is projected that the entire flooded region will undergo reforestation, with the financial requirement for the forestry sector estimated at US$37.5 million. Addressing chemical and pollutant contamination necessitates a comprehensive site assessment, especially downstream of the dam, with initial costs projected at US$10 million. Evaluating affected protected zones, emphasizing red-listed species, demands inspections and field inventories, with a funding need estimated at US$12 million.

## Context

On the early morning of 06 June 2023, the Kakhovka dam, situated on the Dnipro River in Ukraine's Kherson Oblast, was breached, causing a devastating flood downstream of Kherson Oblast, with around 620 km2 (as of 09 June, UNOSAT) affected by flood waters. Although the reservoir was artificial, over the years, the basin became an ecosystem providing several services to the region and the country in general and beyond.

The destruction of the Kakhovka Dam is a fast-moving disaster that is swiftly evolving into a long-term environmental catastrophe for this lowermost reach of the river and delta, with potentially far-reaching consequences on the ecosystems.

The sudden breach of the dam has severely impacted not only the dam's downstream areas but also the upstream regions. The nature of those impacts is varied in terms of severity and the extent of damage.

Many internationally recognized environmentally sensitive and protected zones in the affected areas have been severely impacted. Therefore, this disaster is not just a Ukrainian tragedy but has regional and global implications.

However, dealing with this disaster is also an opportunity for Ukraine to consider the latest climate-friendly technologies, nature-based solutions and build back better. Post-disaster recovery efforts will be ongoing with some immediate mitigation actions, short to medium-term activities including detailed assessments, and long-term reconstruction and rehabilitation activities.

The following paragraphs outline the details of the associated damage, loss, and recovery needs estimates resulting from the disaster.

80. The term "damage" as used by the GoU here maybe more in line with RDNA definition of "loss" than "damage".
81. 4 billion Euros

## *Disaster Effects and Damage and Loss Assessment*

The rapid release of water from the Kakhovka reservoir resulted in a highly destructive flow of water downstream of the dam leading to natural habitat damage, altered river morphology, eutrophication, chemical pollution, and depositing of debris and sediments. In the upstream section, desiccation of the Kakhovka reservoir led to mass die-offs, loss of critical habitats, and lowered groundwater levels, affecting biodiversity and water availability/accessibility.

Because the affected areas are on the frontline and partly under the military control of the Russian Federation, the damages and losses have so far been assessed only through remote sensing and limited on-the-spot analysis. Comprehensive field studies and assessments are needed to accurately determine the extent of the damages and potential mitigation efforts.

The low-sediment production geography and dam's location implied that the sediment released during the flood likely originated from pre-dam riverbed erosion and downstream river corridor. The coastal effects of the sediment plume entering the Black Sea caused high turbidity and could lead to the deposition of fine-grained sediment in coastal areas.

Chemical hazards from hazardous facilities and oil releases are significant concerns, along with potential water and soil contamination from pesticides and fertilizers in the flooded areas. Water quality issues arose due to pollutant release and nutrient influx, reducing oxygen levels and algal blooms, affecting aquatic life.

The breach also had a devastating impact on 75 national- and internationally-recognized protected areas, with many fauna and flora species facing irreversible consequences. The upstream region experienced mass die-offs of aquatic life and destruction of habitats, while downstream areas suffered from habitat losses, water eutrophication, chemical pollution, and water salinity changes.

The disaster resulted in the loss of around 11,294 hectares of forested area, with potential long-term impacts on water resources and microclimate.

### Sediment mobilization

Dnipro River is situated in a low-gradient, low-sediment-production geography, where the Kakhovka dam was the sixth and downstream-most in a series of large dams, implying that the Kakhovka reservoir had quite a low sediment influx. Consequently, the sediment transported to the lowermost river and delta (and the Black Sea) due to the dam-breach flood is more likely to have been sourced from erosion of the pre-dam riverbed above the dam and the river corridor downstream of the dam (entrained during the flood flow), than to have been mobilized from a true reservoir sediment delta.

Coastal effects of the sediment plume entering the Black Sea from the dam-breach flood include high turbidity temporarily, which will limit light in the coastal water column, with associated ecosystem effects. The sediment from the coastal plume is expected to be predominantly fine-grained (silt and clay) and could deposit new mud drapes in coastal areas. The spatial and temporal extent of these morphodynamical changes is presently unknown. Still, the nearshore deposition could impede transportation or economic uses of the shoreline for several months to over a year.

After the dam breach, salinity in the Odesa shore was recorded to be two to three times lower than normal due to the sudden, large inflow of fresh water into the sea. While the salinity is returning to normal, the lower salinity level might have caused the marine organisms' death in the area.

### Chemical hazards

Around 192 hazardous facilities are identified in the flooded area, on both sides of the Dnipro River, with the majority in Kherson Oblast. Of the total number of facilities, 54 are classified as potential hotspots of chemical contamination, comprising primarily large structures that (might have) contained large amounts of chemicals or chemicals of great concern. Biological agents include large-scale livestock and poultry farming and sewage treatment plants. It is only possible to assess whether contaminant release has occurred at these facilities with a site visit.

Around 150 tons of machine oil from the hydropower plant was reported to have been released because of the breach, with the fate of another 300 tons unknown but likely to have been released. As the exact property of the oil is unknown, it is impossible to describe its fate in the water. However, reports indicate a low concen-

tration of oil products in surface water samples taken from the Dnipro River in the Kherson area. A report by ERCC also indicates that an oil slick was removed using dispersants with an estimated 20,000 m2 of surface water area affected. These oil products could have originated from the hydropower plant or other affected infrastructures. Large storages of oil products in the port areas remain a matter of high concern for potentially high levels of contamination. Oil products were also found on the surface of newly formed floodplains in the Kakhovka reservoir.

In addition, potential water and soil contamination is also expected from different sources of pesticides and fertilizers in the flood-affected area. A factory producing and storing pesticides is listed in the affected area with no further information on the extent of damage to the factory. Pesticides and nutrients may also have been mobilized from the approximately 2000 ha of flooded agricultural land. The storage of obsolete pesticides in the affected area remains a matter of concern. A storage container of liquid fertilizer containing 3500 tons of urea-ammonia is also reported to have been damaged, with no further information available on the release of fertilizer and level of contamination.

## Water quality

Surface water downstream of the dam could be polluted through the release of chemical substances, nutrients, sewage, sediments, or other contaminants. Available monitoring data from the Dnipro River after the dam breach shows that the water's environmental quality is generally still met with most of the criteria below the national guideline values. However, in the weeks following the breach, many samples' biological oxygen demand (BOD) exceeded the guideline values, probably caused by high organic matter content. Increased BOD reduces the water's oxygen level, causing stress, suffocation, and death of aquatic organisms.

Water monitoring conducted by the Institute of Marine Biology in the Black Sea after the dam breach indicates that organic matter is ten times higher than normal. An increased amount of organic matter might lead to a more elevated BOD and lower oxygen levels in the water, even below the critical values for aquatic life. Monitoring also showed that the amount of nutrients in the Black Sea increased after the event, especially ammonium. A possible source of this is flooded sewage plants and sewage systems, where it was reported that sewage from the sewage treatment plant near Bilozerka entered Lake Bile. Nutrients and organic matter might also have entered the water from flooded agricultural lands and large-scale livestock and poultry farms (manure). The presence of surplus nutrients can lead to the formation of algal blooms, which could pose risks to living organisms. There was an indication of an algal bloom beginning to form before the dam breach (JRC, Anticipatory analysis of the dams in Ukraine), and this event potentially exacerbated the situation.

## Protected Areas and Forest

The breach of the Kakhovka Dam and subsequent flooding affected biodiversity and protected areas in five administrative provinces of Ukraine. The largest section of the dried-up Kakhovka water reservoir in the north is primarily shared by Dnipropetrovsk Oblast and Zaporizhzhia Oblast. The narrower southern portion of this reservoir and all flooded areas downstream of the Dnipro River, starting from Kakhovka, belong to Kherson Oblast. The regions affected by long-range waterborne pollution, mainly along the coastline of the Dnipro-Boh estuary and the Black Sea, are in the oblasts of Kherson, Mykolaiv, and Odesa.

Based on rough estimations using global unitary cost for ecosystem services[82], the total annual ecosystem services in affected areas (in five sites listed under the Ramsar Convention and seven[83] sites listed under the Emerald Network) was worth USD 8.5 Billion (in 2023 constant US dollars). Even if a conservative estimate of the impact to the ecosystem services is assumed to be 50%, it would result in an annual loss of USD 4.25 Billion. Such assumptions can only be better defined once the magnitude and severity of the potential environmental impacts and the resulting damages mentioned above are determined in greater detail through comprehensive field studies and assessments. Likewise, it is challenging to determine at this initial stage which damages are irreversible and which may be partially mitigated or compensated through future remediation efforts.

**Forested area**

82. N.C. Davidson, A. A. van Dam, C. M. Finlayason, and R. J. McInnes, "Worth of wetlands: revised global monetary values of coastal and inland wetland ecosystem services" Marine and Freshwater Research, 2019. Link

83. 12 sites listed under the Emerald Network were impacted by the flood and the desiccation of the water. Of these, 7 are considered in the estimation of the Ecosystem Services value, given the availability of impacted area based on the spatial analysis. For the rest, no information is available on the scale and area of impacts.

As per geospatial analysis conducted by the FAO, the total flooded forested area is estimated at 11294 ha, considered to have been lost due to the extended inundation and lack of access to the area. The disaster is expected to impact other non-flooded forested areas in the coming years by depleting groundwater resources and causing a significant shift in the area's microclimate.

Given that these forested areas had no commercial use, only the ecosystem services loss are estimated in this PDNA. The combined economic value of five ecosystem services -recreational, hydrological services, habitat protection for biodiversity, non-wood forest products, and greenhouse gas removal- is estimated at US$451 per hectare per year[84] (in 2023 constant USD Dollars). Based on this, a total US$5.1 Million of ecosystem services loss are estimated per year for the forest sector.

According to FAO analysis, in June 2023, the flood caused high water stress in forested areas of the affected oblasts compared to previous years, despite the absence of a significant rainfall anomaly. This change is considered to have linkages with the desiccation of the Kakhovka Reservoir and raises concerns about the potential impacts on forest health and ecosystem stability.

**Table 35:** Damage and Loss for Forests and Ecosystems

| Item | Total Affected area ('000 ha) | Damage (US$ million) | Ecosystem Services Loss (US$ million) | Loss over 18 months (US |
|---|---|---|---|---|
| Protected area | 333.00 | | 4266.80 | 6394.80 |
| Forested area | 11.29 | | 5.10 | 7.65 |
| **Total** | | | **4272.00** | **6402.5** |

Source: Assessment Team[85].

## *Disaster Impact*

The disaster directly impacted many protected areas of national and international importance, exposing many fauna and flora species listed either under the Ukrainian Red Book or European Red List, or both. It includes at least 59 protected areas with varying levels of legal protection of national importance, including 16 protected areas of international importance, including 12 Emerald Network sites established under the Bern Convention, five Wetlands recognized under the Ramsar Convention as crucial habitats for waterfowl, and one UNESCO-MAB Biosphere Reserve. Some of these locations were partially or almost completely destroyed, resulting in irreversible consequences for their biological diversity. The consequences of the disaster extend far beyond the limits of these five administrative regions and the mentioned protected areas, significantly jeopardizing the coherence and ecological connectivity of the Pan-European Ecological Network (PEEN) on a larger geographic scale.

In the upstream, the desiccation of the Kakhovka reservoir rapidly transformed its mature and fully functional ecosystem into a riverine type of ecosystem in early initial stages of development.

The following is an indicative list of the main potential impacts in the upstream:

- The desiccation of the Kakhovka water reservoir, resulting in the immersion of its littoral and benthic habitats, led to the immediate mass die-off of aquatic plant and animal species and reduced their chances of survival, e.g., the waterfowl;
- Lowering water levels in the reservoir and surrounding groundwaters will destroy or degrade wetland, coastal, and riparian habitats, crucial for rare flora and fauna species. This will destroy plant communities and cause a mass die-off of semi-aquatic and terrestrial animals, particularly waterfowl;
- The desiccated lakebed of the reservoir will be colonized by pioneer vegetation, with the potential establishment of invasive species.
- The emergence of the new Dnipro River watercourse on the desiccated reservoir bottom will cause increased chemical pollution and biological contamination due to reduced water purification capacity compared to the reservoir. Wastewater inflow from

85. World Bank, Government of Ukraine, European Commission. Rapid Damage and Needs Assessment. August 2022. Link
85. The ecosystem services loss for the protected area is calculated based on the Global Unitary cost of wetlands, Link; The ecosystem services loss for the forestry section is calculated based on the RDNA1 methodology.

upstream areas, including the city of Zaporizhzhia, will continue unabated.

- Toxins released by algal blooms will contaminate disconnected shallow ponds on the exposed reservoir bottom.
- Lowering water levels in the Kakhovka reservoir will disconnect irrigation channels, including the North Crimean Canal.

As a result of the event, the water rose downstream from normal levels with a devastating magnitude for the natural habitats and its population of fauna and flora. An indicative list of the main impacts for the "downstream" are as follows:

- The catastrophic flood wave caused significant damage to natural habitats, plant communities, and species. The force of the flood washed away soil, vegetation, and wildlife specimens, leading to drowning or subsequent deaths due to environmental changes. Some animals were even found in the Black Sea, where the increased salinity proved fatal for freshwater species.
- Prolonged immersion of flooded habitats resulted in losses of well-adapted wetland, coastal, and riparian habitats and more vulnerable woodland and grassland habitats. This led to the loss of plant communities and affected breeding/nesting and feeding grounds, indirectly impacting the populations of surviving species.
- The flood deposited debris and sediments, altering the morphology and spatial configuration of both submerged and protruding habitat patches in the river corridor or delta. These changes were crucial for aquatic, semi-aquatic, and terrestrial species.
- Water eutrophication occurred due to the influx of fertilizers, sewage, livestock waste, and nutrient-rich sediments from upstream agricultural lands and the emptied Kakhovka reservoir.
- Chemical pollution of water resulted from the release of fuels, industrial chemicals, pesticides from agricultural areas, and military waste, including ammunition and dislodged land- and sea-mines. These pollutants pose risks to humans, habitats, and wildlife.
- Water and sediments became contaminated by pathogens and toxins, likely amplified by the inundation of sewage treatment facilities, algal blooms, and decaying animal bodies.
- The temporary reduction of water salinity in the Dnipro-Boh estuary and the adjacent Black Sea area, combined with water eutrophication and high temperatures, increased the likelihood of algal blooms in the northwestern part of the Black Sea.

It is essential to acknowledge that the natural habitats, especially aquatic, riverine, and riparian ecosystems, along with their plant communities and wildlife species, are generally resilient to dry and wet seasons, including regular spring flooding. However, the Kakhovka disaster occurred unexpectedly during a particularly vulnerable season of intensive vegetation growth and spawning/breeding for many fish and animal species (such as waterfowl, amphibians, and small mammals). Numerous wildlife species, possibly except birds, were unable to escape or survive the catastrophe, and those that survived likely lost their feeding grounds or prey species due to the event.

## *Reconstruction and recovery needs*

**Recovery and reconstruction needs are estimated for the forestry sector and for capacity building and assessments for the environment sector.**

The rebuilding and re-establishment of the impacted forestry sector encompass several short-, medium- and long-term activities: Before any rehabilitation work is carried out, the entire impacted area needs to be demined, which also entails appropriate training of the personnel to carry out the work. In the short term, the recovery activity includes clearing the area, harvesting impacted biomass, preparing soils in the area, and re-planting more resilient and sustainable saplings. This also includes capacity building of people, equipment procurement, infrastructure building such as nurseries and roads, and the associated transportation costs. In the long term, the area must be cleared of war equipment left behind.

The total flooded forested area is assumed to be reforested. Using the Rapid Disaster Need Assessment approach, the forestry sector need is estimated at US$37.5 Million, including reforestation, nursery, roads and equipment, and assessment and capacity building needs.

**Needs related to chemical and other pollutant contamination** can be estimated only after a comprehensive contaminated site assessment. All industrial and infra-

structure sites located in the affected area should be visited and assessed for evidence of contamination. In addition, a sampling and analysis programme focusing on chemical contaminants in soil has been developed for the area downstream of the dam. This initial rapid sampling and analysis would assess the extent of contamination and more accurately define damages, losses, and needs. The cost of this initial rapid sampling and analysis, coupled with more detailed contaminated site assessments and training for the local authorities on the contaminated site assessment, is estimated at around US$10 million.

**Needs related to the affected protected areas** can be estimated only after thorough inspections, field inventories, and assessments in all affected areas, with a special focus on red-listed species of fauna and flora. Should the security conditions allow, inventory in the coming year's spring season can be valuable for plant communities and species. The need for the assessment and inventory in the protected areas is estimated at US$12 million.

**Recovery and reconstruction needs (US$ million)**

Following Government approved methodology, the Ministry of Environmental Protection and Natural Resources of Ukraine has calculated the damages to natural resources in approximately US$4.36 billion[86]. Due to the limited access to the areas damaged by the flooding, validating the damages included in these calculations has been impossible. Therefore, the recovery and reconstruction needs can, at the moment, be estimated only as in Table 36.

**Table 36:** Estimated recovery needs (Million US$)

Source: Assessment team.

| Category | Type of priority activities | Short term (18 months) | Medium to long term | Total |
|---|---|---|---|---|
| Forestry Sector | Reforestation, equipment, road, nursery, assessment, and capacity building | 3.00 | 34.50 | 37.50 |
| Chemical Hazards | Contaminated site assessment and capacity building on assessment for local authorities | 3.00 | 7.00 | 10.00 |
| Ecology | Assessment and inventory in all affected protected areas | 3.00 | 9.00 | 12.00 |
| **Total** | | **9.00** | **50.50** | **59.50** |

## *Recovery and Reconstruction Priorities in 2023/24*

Should the security conditions allow, de-mining and cleanup of disaster waste across the affected area, including the forestry and environment sectors, should be considered a top priority to enable access to the affected area for further actions.

In forested areas, an initial survey and assessment should be prioritized. The removal of dead trees and plants should follow this. In parallel, establishing a nursery for future reforestation of the area should be prioritized. For the chemical hazards, a contaminated site assessment should be undertaken to identify the extent of contamination and the attributed damage, loss, and needs for recovery.

A national working group or thematic task force involving relevant experts should be established for the protected area. The task force should undertake a thorough assessment of the ecosystems, habitats, and species (with a focus on red-listed species), conducting desk studies and collecting relevant data, followed by field inventories and assessments of all affected areas. This would enable measuring the extent of the damage and loss caused by the flood and identifying the future needs in the sector. Based on the needs, capacity building programmes for the actors involved in the above-mentioned priorities should be carried out.

86. 4 Billion Euros

## Recommendations

It has been close to two months since the catastrophic damage occurred at the Kakhovka dam. The focus of the emergency response team has been rightly on the safety of the affected population and livestock. However, from an environmental recovery perspective, a few immediate actions should be taken if not addressed already.

Where chemical contaminant sheens or free products have been observed, pollution control equipment such as absorbent booms and skimmers should be employed to trap and collect them. Similarly, soil erosion mitigation approaches such as physical barriers can be built in certain crucial areas along the flooded regions. The cost of such mitigation techniques depends upon the extent of the impact, location, the type of contaminant, and the clean-up strategies chosen.

However, the most important action in the immediate term would be the design and implementation of detailed environmental assessments that will provide greater clarity on the damages, losses, and recovery strategies contemplated.

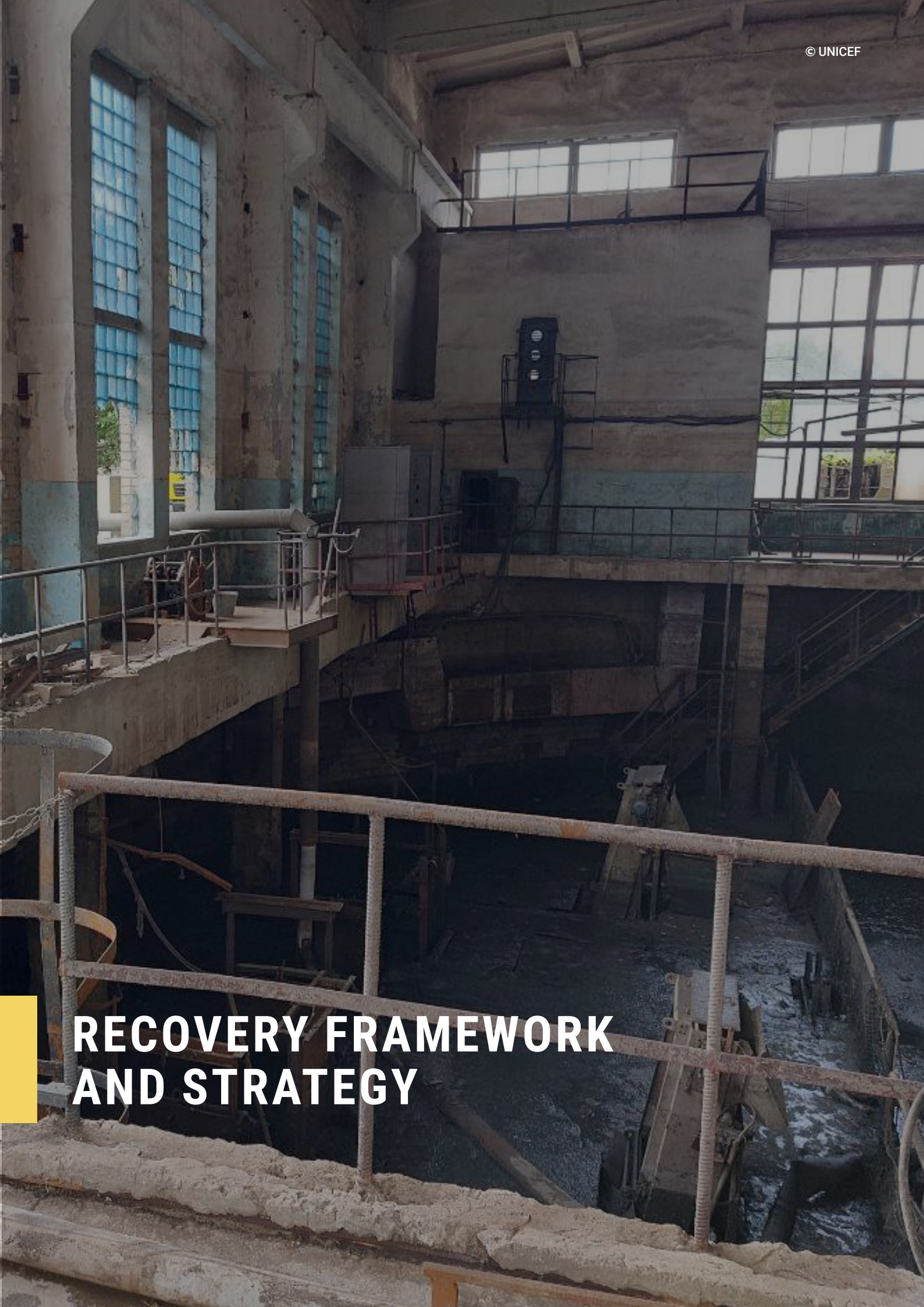
## Limitations

This Chapter addresses several major themes of environmental impact due to the Kakhovka dam breach, including effects on ecology, forestry, and the impacts of chemical pollution. However, other elements have not been included, such as the impact of building damages due to flooding, hazardous air pollution from biological contamination (mold growth), hazardous particulates such as asbestos fibres, and building debris collection and disposal.

Given the nature of the ongoing war in the region, the Dnipro River remains the frontline, and the risk posed by mines is high. Therefore, site accessibility is severely limited, preventing proper field verification activities and data collection; further, because of human resource challenges in relevant agencies, data is limited, slightly dated, or incomplete.

Cost estimates for recovery needs are directly influenced by the extent of actionable data available on damage and loss, which can only be obtained through comprehensive environmental assessments. Therefore, it becomes apparent that the current estimates are of low confidence by default but are the best currently available.

These estimates should be updated as and when relevant additional information becomes available. As noted in the section above, conducting detailed assessments and field verification activities should be prioritised.




# RECOVERY FRAMEWORK AND STRATEGY

The framework for recovery from the Kakhovka Dam Disaster is conceptualized in three stages: Immediate/ Short-term (2023-24), Medium-term (2025-30) and Long-term (up to 2033). The recovery needs for each sector have been conceptualized in these timeframes. This chapter first discusses cross-cutting strategic issues and then outlines the strategy for each stage of recovery and then.

# Crosscutting strategic issues

## *Inaccessible areas*

In many sectors, a significant part of the damage from the dam-breach-induced flooding is in the non-government-controlled areas (NGCA) on the left bank of the Dnipro River. This has constrained the assessment of damage, loss, and needs in those areas, and the estimates provided in this report are probably underestimations. Further, the absence of qualitative and quantitative data about the situation in the NGCA makes it difficult to strategize the recovery process in those areas. It is also possible that the inability to intervene in the NGCA may constrain recovery in a holistic sense and thus hold back recovery in the government-controlled areas (GCA) as well.

## *Integration with reconstruction and recovery from the effects of war*

Recovery from the Kakhovka Dam disaster is an integral part of the Government of Ukraine's strategy for recovery and reconstruction from the invasion by the Russian Federation. Therefore, the recovery framework will adopt the guiding principles for recovery and reconstruction outlined in the July 2022 Lugano Declaration for the Reconstruction of Ukraine. These include partnership, reform focus, transparency, accountability, and rule of law; democratic participation; multi-stakeholder engagement; gender equality and inclusion; and sustainability.

The recovery framework will also follow the set of complementary guiding principles proposed in RDNA 1 & 2, which are based on international experience within post-conflict and post-disaster recovery and reconstruction efforts. These include:

- leadership and coordination by the government and partners,
- balancing urgent needs and medium- to long-term goals,
- differentiated approaches that prioritize impact and needs and that promote decentralization,
- resilience and building back better for a more sustainable future,
- durable solutions for the return of refugees and integration of displaced people, prioritizing their needs for housing, access to basic services, social protection, and livelihoods, and
- continuous data collection.

The RDNA reports emphasize building back inclusively, prioritizing the needs of displaced persons, addressing gender-specific impacts, and caring for veterans and their families. Further, RDNA proposes maximizing private financing for green and resilient reconstruction. While the specific details of the recovery from the dam disaster may be different, it will follow the broad contours of the recovery from the impacts of the war in terms of principles, approach and institutional arrangements.

# Three phases of recovery from the Kakhovka Dam Disaster

## *Immediate/ Short-term (2023-24)*

The main objectives of recovery in the immediate/ short-term (2023-24) are the following:

(i) Enable the return of displaced people.

(ii) Revive key economic activities.

(iii) Protect the most vulnerable groups.

(iv) Initiate action to prevent further damage to environmental and cultural assets.

To achieve these objectives, the following recovery activities are strategically important:

1. **Restore electricity and gas supply** in residential areas, critical infrastructure (health, education, water, sanitation, municipal services, and community infrastructure), and key economic sectors (agriculture, industry, and commerce).

2. **Support short-term rental** housing supply for the return of displaced population and temporary accommodation where needed to support the revival of economic activities.

3. **Provide financial, technical, and logistic support** to revive the productive sector, including agriculture, fisheries, aquaculture, shipping, metallurgy, and other critical sub-sectors. Provide similar support to Cultural and Creative Industries. Focusing on **economic activities that support medium-term recovery and on those that have the greatest multiplier effect** will speed up the overall recovery.

4. **Restore municipal, social, and healthcare services** in residential areas in tandem with population return, prioritizing groups that are vulnerable in terms of **age, gender, and physical and mental challenges.**

5. **Take immediate action to ensure health and safety**, including cleaning up the water supply system and the immediate living environment, demolishing unsafe structures, and removing debris, explosive material, and chemical pollutants. Safety and hygiene in facilities for healthcare and education are of high priority.

6. **Take immediate action to stabilize cultural assets** in danger of collapse, demolition, or further damage, conduct on-field surveys for tangible and intangible cultural heritage and rescue campaigns for damaged and at-risk assets.

In addition to the above-listed priorities, it is also important to initiate detailed assessments, planning, training, and capacity building for undertaking medium-term recovery. Equally important is the task of demining agricultural lands and protected areas, upgrading the Kakhovka Lock infrastructure, and the reconstruction of port facilities, piers, and vessels.

**The total investment envisaged in this phase is US$1.8 billion.**

## *Medium-term (2025-30)*

The first phase of activities sets the stage for the second and most crucial part of the recovery process. Most of the reconstruction and recovery investments are expected to happen in the medium term, with only a few sectors anticipating long-term recovery activities. It is in this phase that Build Back Better is realized, and all the principles outlined in Section 8.1.2 must be followed. While reconstruction and recovery activities in all sectors are expected to be implemented during this phase, the following are **strategic drivers of the recovery process:**

1. **Housing**: Reconstruct, repair, or retrofit over 37,000 houses impacted by the flood.

2. **Energy**: Replace the energy supply lost with the destruction of the Kakhovka Hydro Power Plant, either by rebuilding the HPP or by installing renewable energy systems of equivalent or higher capacity; restoring and enhancing the power and gas networks to meet high standards of efficiency and sustainability; and ensuring safe and stable cooling systems for the Zaporizhzhia Nuclear Power Plant.

3. **Productive sectors**: Revive agricultural production, adapting agricultural practices to the changing climate with alternate methods of irrigation; rebuild logistics and other support infrastructure for all

productive sectors, including agriculture, fisheries, aquaculture, shipping, metallurgy, other industries, and trade and commerce.

4. **Infrastructure and services**: Build a reliable, efficient, and sustainable water supply and sanitation system for the entire affected region; rebuild municipal service infrastructure, restore and enhance services to meet high standards of resilience and reliability.

5. **Health and education**: Rebuild all damaged facilities for healthcare and education; restore services with higher quality.

6. **Environment**: Remove explosive materials and disaster debris from the affected Protected Areas and Forested Areas; harvest biomass from the flood impact; and create enabling conditions for the rejuvenation of the natural environment with flourishing biodiversity.

7. **Culture**: Restore cultural assets; revive Cultural and Creative Industries; and protect and enhance Intangible Cultural Heritage.

**The total investment envisaged in this phase is US$2.2 billion.**

### *Long-term (up to 2033)*

Energy and Culture are the sectors for which long-term recovery needs have been considered essential. The reconstruction of the Kakhovka HPP or an equivalent alternative source and enhancing the power distribution infrastructure are long-term projects. The Culture sector envisages long-term investment in several strategic areas, including (i) damage assessment, emergency documentation, and rescue campaigns for dispersed archaeological artifacts and structural remains, (ii) reconstruction/restoration of cultural assets, (iii) incorporation of culture sector elements in Master Plans of the disaster-impacted areas, (iv) capacity building for professionals, and (v) continued support for CCI and ICH.

**The total investment envisaged in this phase is US$982 million.**

## Conclusion

| Sector | Immediate/ short term - one year (2023-24) | Medium term - 5 years (2025-30) | Long term - 10 years (2023-33) | Total |
|---|---|---|---|---|
| **Social sectors** | | | | |
| Health | 30.90 | 69.10 | | 100.00 |
| Culture | 54.60 | 127.40 | 182.00 | 364.00 |
| Housing | 722.18 | 779.82 | | 1502.00 |
| Education | 56.57 | 5.79 | | 62.36 |
| **Productive sectors** | | | | |
| Agriculture++ | 69.50 | 110.50 | | 180.00 |
| Commerce and Industry | 10.00 | 10.00 | | 20.00 |
| **Infrastructure sectors** | | | | |
| Municipal Services & Community Infrastructure | 87.78 | 204.82 | | 292.6 |
| Energy | 439.40 | 516.10 | 800.50 | 1756.00 |
| Water and Sanitation | 336.91 | 364.01 | | 700.92 |

**Table 37:** Summary of recovery and reconstruction needs (million US Dollars)

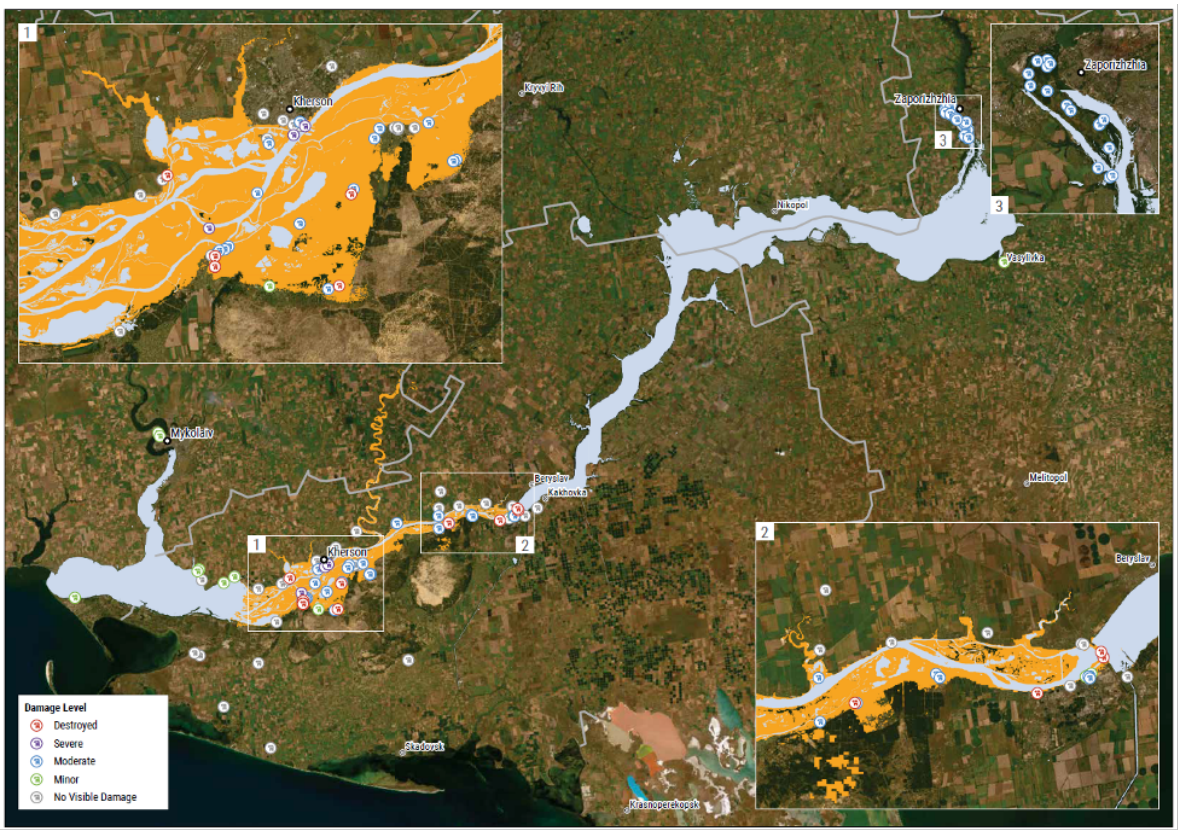
| Sector | Immediate/ short term - one year (2023-24) | Medium term - 5 years (2025-30) | Long term - 10 years (2023-33) | Total |
|---|---|---|---|---|
| **Crosscutting sectors** | | | | |
| Environment | 9.00 | 50.50 | | 59.50 |
| **Total for all sectors** | **1816.84** | **2238.04** | **982.50** | **5037.38** |

As per Table 37, the proposed investment in the first year is almost equal to the investment needed in the next five years. This is mainly because the Housing, Energy and WSS sectors require chunky investments upfront. It is likely that the implementation of these investments would run into the second phase. However, it is important to allocate the funds upfront to allow for mobilizing the massive planning effort needed for the recovery effort.

There are several challenges in mobilizing the recovery effort outlined in this report. First, the hostilities are ongoing, making large portions of the affected area inaccessible and putting at risk the proposed recovery investments, even in the areas controlled by the Ukrainian government. Second, the return of the displaced population is necessary to mobilize the human resources required for recovery. Finally, the institutional capacity to spend US$4 billion in five years is challenging to build in the prevailing circumstances. The people of Ukraine have demonstrated remarkable resilience and determination in these trying times and up to taking on these challenges and more.

# ANNEXES

## *Annex 1 - Satellite image of damaged cultural sites*




© UNESCO classification of damage of cultural sites, OCHA Graphics on Vector flood data: ©UNOSAT 2023 Imagery: © ESRI Online basemap

## *Annex 2 – PDNA Team*

The PDNA team would like to express its deep appreciation to all individuals and organizations who contributed to this assessment.

**From the Government of Ukraine**, support was provided under the guidance of Yuliia Svyrydenko, First Deputy Minister and Minister of Economy of Ukraine; Oleksiy Sobolev, Deputy Minister of Economy of Ukraine for Digital Development, Digital Transformation and Digitalization; Anna Yurchenko, Deputy Minister for Communities, Territories and Infrastructure Development of Ukraine for European Integration; Oleksandra Azarkhina, Deputy Minister for Communities, Territories and Infrastructure Development of Ukraine.

**From the United Nations,** support was provided under the guidance of UNDP and UNRCO.

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| Kyiv School of Economics: Vladyslava Grudova, Max Nefyodov |
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| United Nations: WHO, IOM |
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