

The Kakhovka dam's destruction on 6 June 2023, as a consequence of Russia's war on Ukraine, has led to the flooding of downstream communities, prompting an urgent need for population evacuation and humanitarian assistance. 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 Kryvyi Rih, Nikopol, Marhanets, and other cities and areas. The release of over 18 cubic km of water within a span of 3-4 days poses a significant threat to nearly 80 settlements, potentially affecting around 100,000 inhabitants directly, while up to one million people could lose access to drinking water.

However, the destruction of the dam, beyond these immediate humanitarian needs, will have a significant impact in the longer term on a much larger geographical area and population. It will have severe, long-term impacts on Ukraine's environment, economy and society, including possible displacement and migration of population, and is likely to cast a dark shadow over the country for decades to come.

1. Health, water and sanitation

The Kakhovka reservoir served as a crucial water source for numerous major cities located to the north, west, and south, including Kryvyi Rih, Mykolaiv, Berdyansk, as well as many smaller cities and settlements. The destruction of the dam has disrupted or contaminated the water supply in all these regions. The interruption in water flow has affected not only households but also municipal networks and agricultural irrigation systems in Kherson, Zaporizhzhia, and Crimea.

The flooding poses additional long-term health risks due to discharge of hazardous chemicals from manufacturing plants located downstream. The floodwaters are also contaminated with biological hazards such as sewage wastewater and dead wildlife. This creates a heightened risk of waterborne diseases, including cholera, diarrhea, and others.

The water supply challenges resulting from the dam's destruction may also lead to the temporary closure of health facilities, causing disruptions in essential health services. This situation is particularly concerning for the older population and people with disabilities residing in the area, many of whom have chronic non-communicable diseases. Additionally, the crisis will have a significant impact on the psychological well-being of the affected population directly, but also indirectly on Ukrainian society in general.

2. Chemical hazards

The breach of the dam has resulted in the release of approximately 150 tons of oil products from the hydro power plant, which may spread downstream all the way to the Black Sea. Immediate actions should be taken to install floating booms in areas where the oil is visible in order to contain and pump it as soon as possible. The discharged oil products have the potential to contaminate soil, wildlife, and vegetation, posing a significant threat to natural life and habitats.

The floodwaters will also carry waste from industrial sites, and sewage facilities, as well as fertilizer depots, causing extensive pollution of water and land resources. The State Emergency Service of Ukraine has reported that there are no chemical installations within the potential flooding area. However, there are approximately 64 infrastructure and industrial facilities identified as being in areas at risk of flooding, with 20 of them in high flood risk areas. Although these locations may not store large quantities of chemicals, the flooding of these sites and surrounding settlements, including light industries, storage facilities, garages, agricultural areas, and workshops, may result in multiple small- to medium-scale chemical releases, including pesticides. The process itself of clean-up after flood waters recede also has potential to create secondary contamination if not done according to international standards.

The port area in Kherson city, which served as a significant storage site for fertilizers and chemical cargo, could become a pollution hotspot, not only in its immediate vicinity but also downstream into the Black Sea. The flooded area also encompasses various manufacturing plants that could discharge chemicals into the floodwaters, further exacerbating pollution and health risks. Additionally, the disturbance of bottom sediments

from the reservoir during the flood wave is a concern. These sediments, with a contamination history spanning over 60 years since the dam's construction, may contain heavy metals, persistent pesticides, nutrients, and other pollutants. Proper mapping and assessment of this sediment is crucial to address potential environmental concerns.

3. Agriculture, fishery, and forestry

Initial satellite imagery suggests that many thousands of hectares of agricultural land on both sides of the Dniro River have been affected. If the flooding persists, it could lead to crop losses without sufficient time for replanting during this season. The reduced water levels in the Kakhovka Reservoir will likely have an impact on crop production in Kherson region and other areas surrounding the reservoir in southern Ukraine. Additionally, the reservoir and the upstream Dniro River served as vital fishery resources for the region. Rapid drainage may cause significant damage to these resources, potentially disrupting spawning grounds in the long term.

The forestry resources in the region may also suffer adverse effects. Large areas along the south bank of the Dniro River are home to Crimean Pine, Common Pine, and White Acacia, none of which are well-suited to prolonged moisture exposure. Consequently, these tree species may perish due to the extended period of flooding.

4. Environment

The dam destruction has devastating effects on the ecosystems of the Kakhovka reservoir and the lower Dniro River. Repercussions will extend to the flora and fauna of the Black Sea. An estimated 80,000 hectares of protected areas, including the Lower Dniro natural reserve and Askania-Nova reserves, are at risk of destruction and will be carried downstream towards the Black Sea. This includes several Ramsar wetland sites of international significance, which require special attention and necessitate adaptations to their management plans. The breeding grounds for protected bird species and the spawning areas for fish, particularly within the Kakhovka reservoir, will be significantly impacted, resulting in substantial casualties, especially among fish populations.

Two UNESCO-designated Biosphere Reserves are situated nearby. The Chornomorskyi Biosphere Reserve, located approximately 45 km southwest of Kherson, has already experienced the consequences of the disaster. The Volozhyn forest spanning 203 hectares has been flooded, a 0.5-hectare estate in the town of Hola Prystan has been destroyed, and 500 hectares of the Ivano-Rybalchyn plot and 500 hectares of the Soleno-Ozerna have both been inundated. Ongoing monitoring is being conducted to assess potential threats to the Askania-Nova Biosphere Reserve.

The long-term environmental impacts in the region may include alterations to local climatic conditions due to the loss of a large water body. The dried-up lakebed could release dust and contaminant particles into the air, leading to changes in the local climate.

5. Community Infrastructure, Debris Removal and Mine Contamination

The floodwaters are set to impact over 80 communities, causing irreparable damage to their critical and social infrastructure. These areas will require complete reconstruction before the population can return to their homes. Over 120 educational institutions are at risk due to the flooding. The proximity of these communities to the frontline and ongoing hostilities will pose significant challenges to debris removal and infrastructure reconstruction efforts.

Extensive efforts will be necessary for the removal of debris resulting not only from destroyed infrastructure but also from various forms of natural and man-made waste that have been carried downstream by the floodwaters. This includes the presence of hazardous materials such as asbestos panels widely used in previous construction materials. However, the most pressing and severe consequence of the flooding is the significant number of mines and unexploded ordnance that have been swept downstream and, as the floodwaters recede, now remain scattered throughout the affected communities, resulting in new low-density

non-recognized mine fields. The flood-affected area already had a considerable number of confirmed mine fields, and numerous others remain unconfirmed. Given the circumstances, it can be assumed that all of these mines have shifted and settled in the silt, rendering the entire flood zone a contaminated area, complicating detailed assessments and remediation efforts, leaving many people unable to return and those who remain at risk of diminished livelihood opportunities and longer-term need for social protection services. For those with specific vulnerabilities, such as the elderly or those with a disability, access to key services may be cut off, increasing needs in both the immediate and longer term.

The flooding may also impact local media outlets, further limiting access to critical and verified information for the affected population, including information on mine contamination, chemical hazards and water availability, humanitarian assistance, evacuation efforts, etc. While the exact number is being verified, it is estimated that around ten media organizations were directly based in the flooded areas, according to the Ukrainian Media Business Association (UMBA).

6. Energy

The breach of the dam has resulted in the loss of the Kakhovka hydro power plant (HPP), a crucial source of clean energy for southern Ukraine. The reconstruction of the HPP is estimated to cost more than 1 billion USD. While the HPP has already been disconnected from the main power system of Ukraine, the consequences of this disaster are significant. The destruction of the Kakhovska HPP in the long term diminishes the automatic frequency restoration reserves within Ukraine's power system, making system balancing more challenging and costly. The flooding has caused the destruction of electricity infrastructure, leaving approximately 20,000 residents without power. Moreover, there is a risk of the Kherson Heat and Power Plant being affected, which could impact around 140,000 individuals.

Furthermore, the Zaporizhzhya Nuclear Power Plant (ZNPP) relies on water from a reservoir directly connected to the Kakhovska HPP's reservoir. The potential loss of the primary cooling water source further exacerbates the already challenging nuclear safety and security situation.

7. Housing

The extensive flooding has inflicted severe damage to residential properties, leading to both immediate and long-term housing challenges. The depth of the floodwater, averaging over 3 meters, is expected to cause significant harm to more than 2,500 homes. As of now, more than 200 houses have been confirmed as destroyed, but this number is likely to increase substantially once the water recedes and access to the affected areas can be secured. Given the circumstances of the evacuation, it is to be expected that many people have been left without documentation that may be crucial to access services, especially if displacement becomes extended.

The structural integrity of houses will be compromised, resulting in various forms of damage. The foundations of the buildings will be eroded, walls weakened, and load-bearing structures compromised. Consequently, cracks, sinking, or even collapse of houses is already being observed and may occur further. In many cases, repair and rehabilitation of the affected houses may not be feasible, necessitating costly and time-consuming debris removal and reconstruction efforts. The overall impact on housing will involve both immediate needs for alternative housing options and long-term reconstruction projects to restore the housing stock to pre-flood condition.

8. Internal displacement and potential of out of country migration

One of the immediate as well as medium term impacts of the destruction of the dam will be further displacement of the population from the affected areas which may eventually lead, at a later stage, to a more consolidated process of internal and possibly out of country migration. Initial assessment indicates that 2,200 people have been displaced from their place of habitual residence in flood-affected areas and 81 per cent of those remain currently within Kherson region. However, the lack of adequate housing, access to clean water

and environment, risks posed by mine contamination, loss of livelihood opportunities and food insecurity as well as the overall insecurity in the region could impact mid- to long-term mobility decisions. It is anticipated that climate displacement and migration may prompt up to 400,000 people to leave the southern regions of Ukraine in the coming years. Immediate as well as midterm solutions for livelihood opportunities, shelter and housing and sustainable access to essential services, will need to be identified to prevent massive population displacement and internal/external migration from this region.

9. Culture

Approximately fifteen museums, archaeological sites, and historical locations could be directly affected by the floodwaters. Among the areas being examined to evaluate potential damage are Nova Kakhovka, Korsunka, Dnipryany, Lviv settlement (4th century BC - 4th century AD), Burgun settlement, Mykolaivka village (2nd-5th centuries), Tyagin fortress site, Tyaginka village (13th-17th centuries), and the historic settlement of "Ponyativske" in Ponyativka village (4th century BC - 4th century AD). The flooding is likely to result in structural damage and the weakening of these cultural institutions. Archival collections and moveable heritage are also at risk of deterioration, compromising their integrity and making them susceptible to looting and illicit trafficking.

In order to determine the exact scope of the potential impacts described in this analytical note, the United Nations in Ukraine is partnering with the Government of Ukraine, the Kyiv School of Economics and the European Union to produce a comprehensive assessment of the devastating long-term impact of this disaster across sectors, looking at damage to infrastructure, services, livelihoods and people. For more information, please contact Ana Lukatela, Head of the UN Resident Coordinator Office ana.lukatela@un.org.