



# GIEWS Update

## Ukraine

### Flood waters from the breach of the Kakhovka Dam receded, but concerns remain for future agricultural production

#### Highlights

- The Kakhovka Reservoir, part of the Dnipro cascade of hydroelectric power plants, was an important source of water for arid regions in the southern part of Ukraine.
- Flooding after the breach of the Kakhovka Dam on 6 June 2023 resulted in relatively limited losses on agricultural production but long-term consequences for irrigation remain, including for maize and other irrigated crops planted in spring 2023.
- The consequences of the breach raise serious humanitarian, environmental and economic concerns for the region.

#### The Kakhovka Reservoir: An important source of water for arid regions

The Kakhovka Hydroelectric Power Plant (HPP),<sup>i</sup> located near the city of Nova Kakhovka in the Kherson region in the southern part of Ukraine, was the last one in

the series of six dams in the cascade of HPPs on the Dnipro River, including also Kyiv, Kaniv, Kremenchuk, Kamianske and Dnipro. The construction of the cascade bridged over half a century, forming an important nexus for ecological and economic systems in the region.

Map 1: Part of southern Ukraine – Location of Kakhovka Dam



Image: Planet Scope May, 2023

Source: Planet and NASA Harvest, May 2023 <https://www.planet.com/pulse/navigating-the-kakhovka-dam-collapse-nasa-harvest-consortium-assesses-agriculture-impacts-with-satellite-imagery/>.

Through out the year, the Kakhovka Dam, stretching 3.2 km, ensured the regulation of the flow of the Dnipro river for power generation, irrigation and water supply to Kherson, Mykolaiv, Zaporizhzhia and Dnipropetrovsk, four southern arid regions. It also facilitated navigation between Kherson to Zaporizhzhia. The reservoir held an estimated 18 cubic km of water, while in 2021 the HPP supplied 0.7 percent of Ukraine's overall energy balance.<sup>1, ii</sup> Although its overall contribution to energy generation was small, the HPP acted as a regional stabilizer during the peak load regulation. The reservoir provided water for the essential cooling of the six reactors of the Zaporizhzhia nuclear power plant,<sup>iii</sup> as well as of spent fuel and emergency diesel generators that have had to be used repeatedly when external power fails. Since the start of the war in February 2022, the control of the plant was not with the Ukrainian government and, since October 2022, the HPP was not producing electricity for the United Energy System of Ukraine.<sup>iv</sup>

Following the completion of the Kakhovka reservoir in 1956 and its network of irrigation canals, creating the largest irrigation system in Europe, drought-prone southern steppes became an important and reliable producing region. Kakhovka and North Crimea canals<sup>v</sup> are the most significant ones, with Kakhovka Canal (sometimes referred to as South Ukrainian) irrigating 326 000 hectares in Kherson and parts of Zaporizhzhia.<sup>vi</sup> The North Crimean Canal irrigated 39 700 hectares of agricultural land. Dnipro-Kryvyi Rih Canal supplied the Dnipropetrovsk Region, while the Verkhnio-Hachynsky Canal supplied the northern Zaporizhzhia Region.

The reservoir provided water supply to 31 irrigation systems<sup>vii</sup> consisting in total of over 12 000 km of canals in Dnipropetrovsk, Kherson and Zaporizhzhia regions. In 2021, prior to the start of the war in February 2022, the reservoir provided irrigation for 584 000 hectares on both sides of the Dnipro River, from which about 4 million tonnes of grain and oilseeds were harvested. Irrigation tends to be used more on spring and summer crops, utilising water accumulated in the reservoir from melted snow. Although crops in the Mykolajev Region were not directly irrigated with water from the Kakhovka reservoir, they take advantage of good soil humidity benefits due to the close proximity of the reservoir. In 2023, 13 irrigation systems were operational on the right bank of the Dnipro River, area under control of Ukraine.

Although not all cereal and oilseed crops were irrigated, the regions of Kherson, Zaporizhzhia and Mykolajev were significant producers of wheat, barley, rapeseeds, sunflower and relatively small quantities of millet. Before the start of the war, Kherson, Zaporizhzhia and Dnipropetrovsk regions accounted for about 20 percent of the country's wheat and barley production and about 18 percent of rapeseed production. Maize and soybeans crops, planted in spring, are normally irrigated, while sunflower, also planted in spring, is usually grown as rainfed. Southern regions also produced a significant share of fruits and vegetables, including grapes, eggplants, onions, peppers and cucumbers, all entirely irrigated.

### **The breach of the dam: Its impact on agricultural production**

While immediate losses of crop production as a direct result of flooding have been relatively limited, the destruction of the infrastructure carries long-term consequences for the region, especially for irrigated agricultural production, including 2023 spring crops.

Following the retreat of the Russian troops towards the eastern part of the country in April 2022, the Dnipro River became *de facto* the frontline of the conflict. Active fighting and military ordnance limited substantial agricultural production in the immediate vicinity downstream from the reservoir. Nevertheless, smaller scale, mostly backyard style, crop and livestock production has been taking place in areas along the frontlines mostly in the rural households. Flooding is likely to have lasting consequences on livelihoods of small-scale farmers and households that were still active in the area and, given the circumstances, are unlikely to have sufficient resilience capacity to recover when flood waters recede.

By the time of the breach of the dam on 6 June 2023, winter wheat, barley and rapeseed crops, particularly in areas south of the reservoir, were ripening. Under non-conflict circumstances, significant flooding at the near harvest time would likely result in a complete loss, but due to limited planting, the evidence so far is not pointing to large-scale damages. Although parts of Kherson and Zaporizhzhia regions returned under the control of the Ukrainian government in autumn 2022 in time for winter crop planting, the need for demining in many cases prevented widespread cultivation. The regions of Dnipropetrovsk and

Mykolaiv together accounted for up to 22 percent of the fields planted with winter grains in Ukraine, although those were not directly affected by floods.

In the south, the 2023 spring crops (maize, soybeans, sunflower) were planted in April–early May, and there is a good chance that they were already established and could survive flooding if not waterlogged for a long time. However, depending on rainfall amounts during the rest of the 2023 growing season, the lack of irrigation for spring planted crops is likely to constrain yields and reduce total production. About 300 000 hectares (out of a total 4 million hectares) of maize were planted in areas dependent on water from the Kakhovka reservoir. In a worst case, but unlikely scenario, assuming a total loss of crops in this area and using a conservative yield estimate of 5.5 tonnes /hectare, the total maize production of the country would decrease by about 1.6 million tonnes.

Although no direct information is available about plantings on the left bank of the Dnipro River, satellite images from May 2023 indicate that planting took place and at least some fields were irrigated using pivot irrigation systems.

Although total storage capacities for more than 100 000 tonnes are situated close to the Dnipro River, only some damages to elevators and storage facilities have been reported. In terms of logistics, shipping from the ports of Danube River and Greater Odessa has not been affected. The interruption of navigation from Kherson to Zaporizhia because of the breach could increase costs for operators. Nevertheless, the use of the Dnipro River for commercial navigation in the past year was constrained due to the proximity of the active frontline, leading to further increases in inland shipping costs.

First reports from the Ministry of Agrarian Policy and Food of Ukraine<sup>viii</sup> indicated that approximately 10 000 hectares of agricultural land on the right bank of the Kherson Region (under the control of Ukrainian government) were flooded. However, owing to topography, as seen from earth observation images, the extent of flooding the left bank was larger, although more precise information is not available. Based on high definition remote sensing images, NASA Harvest<sup>x</sup> estimated that, as of 7 June 2023, the total flooded area was around 410–420 square

kilometres (41 000–42 000 hectares), including about 3.5–5 km<sup>2</sup> (or 350–500 hectares) of croplands.

While immediate damages for landowners and workers have a significant impact on livelihoods, further eroding the resilience of the agriculture and rural households, long-term damages stemming from the disruption in the irrigation system raise concerns about the viability of the agriculture sector in the affected areas. As a result of the dam destruction, the ability of farmers to irrigate crops in the southern part of the country has been seriously curtailed. Damages to the infrastructure of reclamation systems and canals as a result of the destruction of the Kakhovka HPP are estimated at UAH 150–160 billion (corresponding to USD 4–4.3 billion).<sup>x</sup>

In the long term, the use of irrigation systems will remain constrained, unless the water in the reservoir increases to levels which make pumping feasible. The breach of the dam left<sup>xi</sup> 94 percent of irrigation systems in Kherson, 74 percent in Zaporizhzhia and 30 percent in Dnipropetrovsk regions without a water source, affecting future agricultural activities in the region. Analysis of satellite images indicate that most irrigation canals are disconnected from the reservoir (or what remained from it) and it is likely that the pumping equipment was damaged by flood waters. Making the reservoir functional again will require at least temporary repairs to the structure aimed to lift the water level.

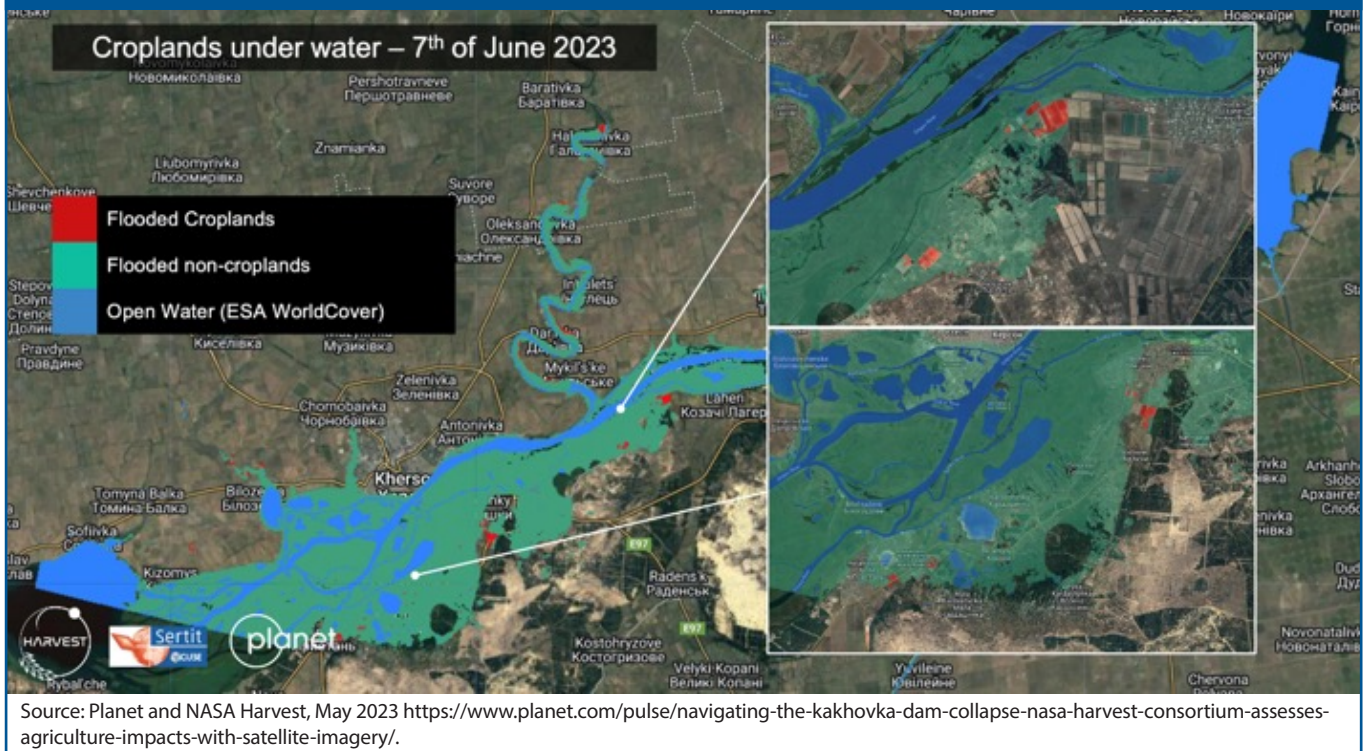
### **The breach of the dam: Its humanitarian, environmental and economic consequences**

The breach of the Kakhovka Dam caused widespread flooding, immediately endangering human settlements, economic activities and the supply of drinking water in the region. The consequences of the dam's destruction carry immediate and long-term humanitarian, environmental and economic impacts, including on agricultural production.

In areas under Ukrainian control, flood waters receded from a 5.6 metres peak on 8 June to 1.6 metres on 15 June and further since then. Humanitarian efforts, including evaluation of damages and distribution of humanitarian aid, have been hampered by heavy rains in the area. Over 3 600 people were evacuated from the flood zone by Ukrainian authorities. The



Map 2: Part of southern Ukraine – Flooded areas as of 7 June 2023



number of human casualties remains unknown. Despite the lowering water levels, as of 14 June, 46 towns and villages remained flooded in Kherson region, including 32 in the Ukraine-controlled right bank of the Dnipro River, 14 in the areas under Russian military control and 31 in Mykolajev Region. By 15 June, 13 towns<sup>xii</sup> and villages were still flooded in the Ukraine-controlled parts of the Kherson Region. By late June, flood waters receded.

The reservoir provided drinking water supplies for about 700 000 people<sup>xiii</sup> in the southern part of the country. As water levels in the reservoir dropped by 70 percent by 15 June, drinking water shortages were already reported in the area. Following the breach, the width of the reservoir decreased from 3 to 1 km, and the water level (as of 15 June) was at 7 metres, well below the threshold of 12 metres necessary for pumping. The extent of structural damages and water contamination will have long-term consequences on the provision of drinking water in the region. Shortages of piped drinking water can amplify other humanitarian needs that were already present in the area, such as related to health.<sup>i</sup>

While the energy generation system of the country has been reported to be stable, shortly following the breach, upstream hydroelectric plants are

operating at reduced capacity to limit risks of further flooding. Water was also being accumulated in the upper reservoirs to reduce the scale of the damages downstream.<sup>xiv</sup>

Floods, in addition to washing away fertile upper soils, moved sediments from the reservoir and other water bodies, altering soil composition. Contamination of water and soil is likely: 150 tonnes of machine lubricants were washed into the Dnipro River from the HPP itself, and there is risk of further leakage of more than 300 tonnes of oil.<sup>xv</sup> Although no major chemical factories were located along the flooded area, runoff from storage of lubricants, fertilizers and other contaminants is likely, including from storage facilities close to ports. Flood waters also washed away mines. While eventual sea mines, previously anchored in the reservoir along the frontline, are unlikely to accidentally detonate, displaced landmines (both anti-tank and anti-personnel) pose a serious risk for the local population and are likely to further thwart rescue and clearing efforts.

The reservoir, its water discharge canals and the accumulating ponds were also used for fish farming. Losses for the fishing industry due to the death of only adult fish were estimated at 95 000 tonnes, worth about UAH 4 billion (approximately

USD 108 million).<sup>xvi</sup> Beyond the immediate death of fish in the reservoir as well as that of wildlife, long-term implications on biodiversity are likely due to changing ecosystems around the Dnipro River, which included also rare species. As flood waters receded, fresh (as opposed to marine salty) flood waters contaminated with debris, chemical and biological material, including pathogens, has made its way to the Dnipro-Buza estuary system and the Black Sea, with broad implications for ecosystems.

## Implications

Rainfall is unlikely to provide sufficient and timely distributed amounts for reliable agricultural production, and lack of irrigation carries risks of increased production volatility in the region. The destruction of the reservoir also increases risks of seasonal floods, particularly in the spring period following the snow melt. Should the disruption in the irrigation system last several seasons, the immediate restart of the agricultural production is unlikely, as soil salinity might have increased in the meantime.

Lack of irrigation, prompting changes in cropping patterns or even causing land abandonment in some areas, could increase soil erosion with cascading environmental and social effects. Significant changes in production will have impacts on rural livelihoods, infrastructure, market access and the overall fabric of rural areas which in the past relied on the reservoir.

Limited livelihood opportunities could contribute to increased migration. Directly, the food security situation of the rural population, which heavily

relies on backyard gardening and small-scale food production for dietary diversity, calorie intake and income generation, is likely to be negatively affected. Long-term consequences will also include environmental damages, constraining soil fertility and loss of biodiversity.

Although Ukraine's production and export potential has been constrained by the implications of the active conflict, the country remains a significant player in world food markets. In the 2022/23 marketing year (July–June), about 67.8 million tonnes of agricultural commodities were exported, including 29.5 million tonnes of maize, 16.8 million tonnes of wheat and 5.4 million tonnes of sunflower oil.

Immediately following the breach of the dam on 6 June, prices quotations for wheat and maize on the Chicago Board of Trade (CBOT) increased due to raising concerns about Ukraine's supplies.<sup>xvii</sup> By contrast, on the Euronext exchange, wheat quotations did not undergo significant changes, presumably because immediate damages were rather limited.

Although it is not foreseen that the loss of previously irrigated crops in the south would have a significant impact on world markets, the actual impact will largely depend on production developments in other main producing countries that contribute to availability on the global markets. Nevertheless, disruption in irrigation on both sides of the Dnipro River will have a significant effect on the production of nutritious high value foods, such as fruits and vegetables, sold mostly on the domestic markets.

## Notes

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