Flood Risks in Ukraine in 2024

Nationwide assessment and conflict-sensitive disaster risk management approaches

February 2024 | Ukraine

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Introduction

Since the onset of the full-scale Russian invasion of Ukraine in February 2022, the Government of Ukraine (GoU) has largely concentrated its attention and resources on addressing the conflict's immediate impacts, such as security and defense, managing large-scale displacement of population, addressing widespread humanitarian needs, and ensuring the continuity of essential services. The urgency of these challenges might inadvertently overshadow other external threats, such as natural hazards, whose consequences may in turn exacerbate conflict impacts in the context of overall reduced systemic resilience.[1] A significant concern for Ukraine is the threat of flooding, which according to climatic projections is likely to be amplified by climate change.[2]

Approximately 27% of Ukraine's territory is prone to flooding.[3] This susceptibility is exemplified by recurring severe floods in the Carpathian Mountains and their surroundings. The 2020 Western Ukraine floods, for example impacted 277 settlements affecting and estimated of 30,000 people.[4] More recently, in April 2023 seasonal rise in the Dnipro, Desna, Seym, Sozh, Pripyat and Horyn rivers resulted in the flooding of 950 households across Volynska, Dnipropetrovska, Kyivska, Rivnenska, Poltavska, Cherkaska, Chernihivska and Zhytomyrska oblasts, serving as a reminder of the natural hazards to which Ukraine's population continues to be exposed during wartime.[5]

Against a backdrop of challenges in flood protection and water management systems pre-dating the full-scale invasion, war-related damage to infrastructure and resource constraints have combined to reduced systemic resilience, thereby increasing the potential impacts of flooding across Ukraine.[6] By December 2023, the damages and losses to irrigation and water management systems were estimated at USD 1.46 billion.[7] Given continued ground hostilities, especially in the East and South, alongside ongoing air strikes and the threat of anthropogenic disasters like the Kakhovka Dam breach, the likelihood of further preventable flood damage is high. Minimising future flood damage will require the repair and enhancement of essential water management infrastructures in areas under the control of the GoU.[8]

The extensive damage to residential areas and the ensuing humanitarian crisis has further compounded the potential impact of natural hazards. The conflict has severely affected the country's housing sector, with an estimated USD 73.3 billion in damages and losses by December 2023.[9] Furthermore, the war had caused massive displacement, with approximately 3.7 million internally displaced persons (IDPs) by October 2023.[10] Infrastructure damage, displacement and insecurity have increased socio-economic vulnerabilities, disrupted livelihoods, and heightened humanitarian needs.[11] According to REACH's 2023 Multi-Sectoral Needs Assessment (MSNA), 7% of households across the country faced extreme needs in shelter and non-food essentials,[12] while the Ukrainian Red Cross Society reported that 10 million people required shelter assistance.[13] These factors can significantly decrease people's resilience and capacity to cope with additional stressors, such as flooding events.

Ahead of the 2024 flood season in Ukraine (March-May),[14] it is crucial to assess how flood impacts may be exacerbated by cumulative infrastructure damage, humanitarian needs, changing demography, as well as understand additional operational challenges faced by emergency responders, such as delays in accessing impacted areas and populations due to damaged transport infrastructure.[15] The convergence of war impacts and flood susceptibility can also impede recovery efforts in the aftermath of flood events, further compounding vulnerabilities of communities, who have to face the dual burdens of war-related damage and flood impacts.[16]

Image 1. Shallowing of the Kakhovska Reservoir after the dam breach in June 2023. Source: Sentinel-2.[17]

Objective and utilisation

This report aims to support preparedness, humanitarian response and recovery efforts in relation to flood risks in Ukraine in 2024. Specifically, it:

- Identifies areas at risk of significant flood impacts due to a combination of natural susceptibility and conflict-related vulnerabilities.
- Assesses how the protracted conflict in Ukraine has affected systemic resilience and capacities (at the household and institutional levels) to withstand and manage flood risk.
- Highlights modalities for enhancing localised flood resilience in the identified "flood hotspots".

Image 2. Flood level visible at on a home in Halytska, Ivano-Frankivska oblast.

The following sections outline conceptual frameworks promoting an understanding of the convergence of conflict and natural hazards impacts, enabling the integration of conflict-sensitive disaster risk management (DRM) measures into humanitarian and recovery programming in Ukraine. In parallel to this nationwide assessment, REACH is conducting in-depth area-based assessments in two hromadas identified as being at elevated risk from the effects of flooding in the context of war. This information can support various stakeholders in reducing flood risks in Ukraine in 2024, specifically:

- **Humanitarian actors:** Supporting response planning and resources allocations for the flood season, and enabling the integration of DRM into humanitarian response.
- **Government authorities (national and local):** Supporting the development of policies and action plans that consider both conflict and flood risk, enhancing community awareness, and focusing on developing long-term resilience.
- **Emergency responders:** Enhancing operational readiness and risk communication.
- **Donors:** Supporting evidence-based strategic funding planning considering multiple risk factors, including natural hazards.

In addition to assessments, REACH also support the operationalisation of conflict-sensitive DRM measures in various areas of Ukraine through capacity building and direct analytical support at the local level.

Key findings

- The **conflict in Ukraine amplifies vulnerabilities to natural hazards**, creating situations of **double vulnerability** where the impacts of both conflict and climatic disruptions exacerbate each other.
- **Flood susceptibility in Ukraine is uneven** and varies according to geomorphological and hydrometeorological factors. **Areas with the highest susceptibility are in the mountainous regions in the West and North** of the country.
- **Populations in western and northern regions of Ukraine are most susceptible to the impacts of flooding** due to their proximity to flood-prone areas and the presence of large numbers of internally displaced people (IDPs), youth, and elderly populations.
- **Lack of coping capacities (LOCC) exacerbates vulnerability to flooding, particularly in frontline areas bordering Russia and occupied territories**, where conflict-related incidents have led to large-scale damage and destruction of critical infrastructure, including water-regulating facilities. As of January 2024, five water reservoirs dams had been affected, with four of these in the East and South of the country, near the conflict's front line.
- The Flood Risk Index (FRI) enabled the identification of the **five hromadas with the highest flood risks**, **Halytska, Oleshanska and Tiachivska** in the West, **and Chernihivska and Zazymska** in the North. There is a need for targeted DRM interventions in these areas.
- Further **analysis and tailored flood management measures are needed** to address the specific risk profiles of critical hromadas and mitigate the potential impacts of future flooding events.

Methodology

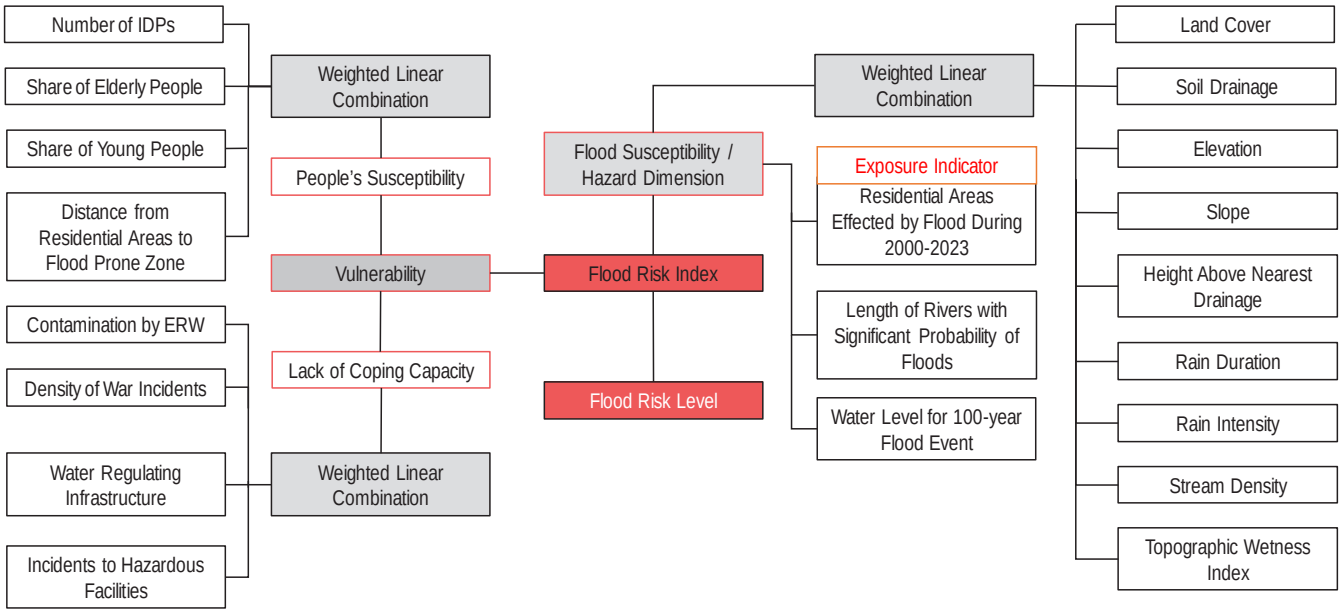


Diagram 1. Flood risk calculation workflow.

This assessment covers areas under the control of the GoU as of 20 November 2023. It uses a multi-layered methodological approach combining secondary data analysis with expert consultations, grounded on a standardised flood assessment methodology,[18] adapted to the local context, which accounts for indicators of hazard exposure and vulnerability (as a combination of susceptibility to floods and lack of coping capacity) to assess risks. These three components were overlaid to calculate a "Flood Risk Index" (FRI) at the hromada (admin 3) level using the following formula.

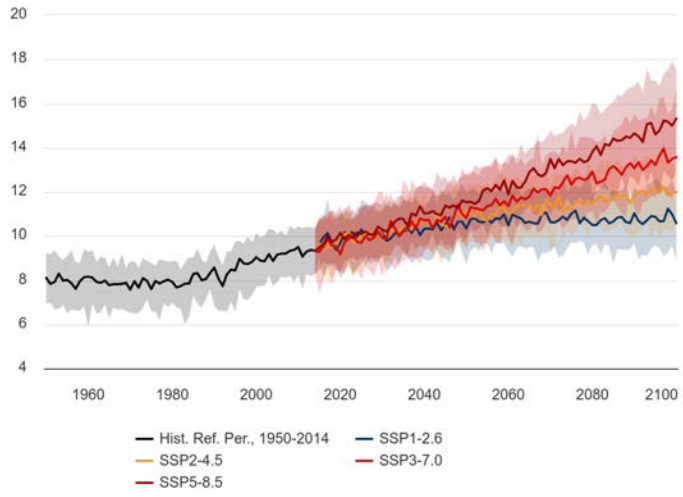
$$\textbf{FRI} = \text{Hazard} \times \frac{(\text{Susceptibility} + \text{LOCC})}{2}$$

FRI values were then classified in five classes (from 'Very Low' to 'Very High') to rank hromadas accordingly. Refer to the methodology note (Annex) for further details about the data sources, indicators, processing steps undertaken, and known limitations.

Climate change and precipitation levels in Ukraine

Human activities, primarily greenhouse gas emissions, have undeniably driven global warming, pushing the global temperature 1.1°C above pre-industrial levels by 2011-2020. Greenhouse gas emissions have continued to rise, fueled by unsustainable energy, land use, and consumption patterns. This human-induced climate change is already altering weather patterns worldwide, leading to adverse impacts on food and water security, health, economies, and societies, causing significant losses and damages to nature and people.[19]

Ukraine faces complex climate change impacts, with noticeable shifts in temperature and precipitation patterns. Rising average temperatures, depicted in the graph below using Shared Socioeconomic Pathways (SSPs),[20] contribute to changing seasonal climate dynamics. This warming trend contributes to higher winter and spring temperatures, resulting in rapid snow melt and increased flood risk. The SSPs represent possible future scenarios, ranging from low (SSP1) to high (SSP5) emissions, exploring possible outcomes based on global cooperation and socioeconomic development levels.[21]

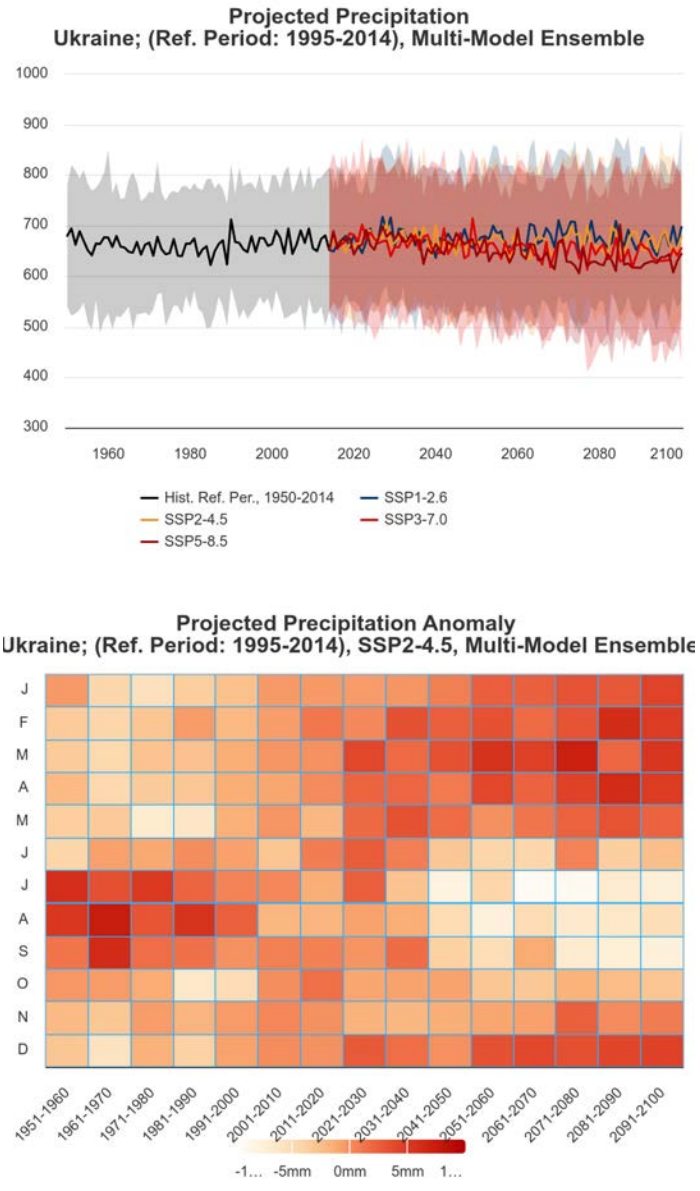


Graph 2. Projected average mean surface air temperature °C in Ukraine. Source: World Bank.[22]

Changing precipitation patterns, driven by climate change, bring increased variability and intensified extreme weather events, constitute a challenge for water resource and flood management in agriculture and urban areas.[23] Warmer global temperatures increase the potential for heavy rainfall, as warmer air can hold more moisture. This heightens the risk of frequent intense events, and

therefore flooding. Exceptions occur only in areas where precipitation decreases significantly, leading to a shift in the return periods of large events.[24]

The projected change in seasonal precipitation for Ukraine indicates an increase during the wettest season (March-May), period of re-occurring floods, snowmelt, and river level rise. For 2020-2039, a 4.2% increase in precipitation, and for 2040-2059, a 5.2% increase are anticipated under the SSP2-4.5 scenario (most likely). The graphs below depict Ukraine's projected precipitation changes until 2100. The top graph shows mean changes under various SSP scenarios, while the bottom graph illustrates monthly precipitation anomalies under SSP2-4.5 (middle scenario). It highlights that wetter months will get increasingly wetter, amplifying flood risk conditions, and drier months will get increasingly drier, amplifying drought conditions. These changing climatic patterns resulting in increasing flood risks should be considered in long-term disaster risk management efforts, particularly in the context of the ongoing conflict.



Graph 3. Ukraine's projected precipitation until 2100. Source: World Bank.[25]

Flood risk and conflict

Flooding is one of the world's most common natural hazards due to its frequency and wide geographical occurrence. Although most flood events are small, major flooding occurs regularly, causing an average of USD 40 billion in losses every year.[26] The magnitude of a flood depends on multiple factors, such as precipitation levels, soil and water stream conditions, topography, land use, vegetation cover, the capacity of local drainage systems, among others. Climate change is heavily disrupting natural climatological and hydrometeorological patterns, with consequences for flood probabilities and intensities as a result of precipitation changes, storms, and sea-level rise.[27] These changing patterns create greater uncertainty, bringing significant challenges at all stages of the DRM cycle (prevention/mitigation, preparedness, response, and recovery).

The multifaceted and long-term repercussions of armed conflicts introduce additional layers of complexity to climate change impacts. This interplay can generate situations of double vulnerability, whereby the impacts of both phenomena reinforce each other. For instance, in conflict zones, infrastructure damage, displacement, disrupted livelihoods, and compromised access to essential services can hinder a community's ability to cope with and recover from disasters. Illustrating this interplay, it is estimated that 58% of people who die from natural hazards each year live in the world's 30 most fragile states.[28]

The case of Syria

In 2020, Northwest Syria was impacted by large-scale floods affecting thousands of people, who were already experiencing the effects of a decade-long conflict, such as displacement and economic collapse. Many were residing in temporary settlements with difficult living conditions, located in hazard-prone locations and with a lack of functional public services such as drainage systems. Such a combination of vulnerabilities resulted in these settlements, and their populations, being the most impacted by the flooding.[32]

Countries experiencing conflict receive comparatively little support for DRM,[29] while government resources are often diverted away from such efforts towards addressing pressing security threats. This can result in a lack of adequate prevention, mitigation and preparedness measures to natural hazards, and reduced capacities to address their immediate consequences (response) and longer-term repercussions (recovery).[30] Contexts of armed violence are usually considered complex environments to deliver risk reduction programmes, while the urgency of the conflict often relegate DRM to a lower order of priorities by stakeholders, including governments and international organisations.[31] Illustrating this, a key informant (KI) interviewed by REACH mentioned that since the start of the Russian invasion in February 2022, no water and flood management technical assistance projects had been initiated in Ukraine.

"The war affected only funds. If some construction had been planned earlier, now it is clear that all these expenses are going to war. I don't even know if funds will be allocated if there is a flood, and what amounts it will be".
- KI, former member of both the Ministry of Environmental Protection and Natural Resources, and the State Agency of Water Resources of Ukraine.

Understanding the nexus between conclict and natural hazards is crucial for devising comprehensive strategies that address the dual challenges ensuring resilient communities and effective disaster response and recovery initiatives. However, this is rarely the case since there is not much information about how conflict exacerbates people's vulnerability to natural hazards, while hindering disaster management programmes.[33]

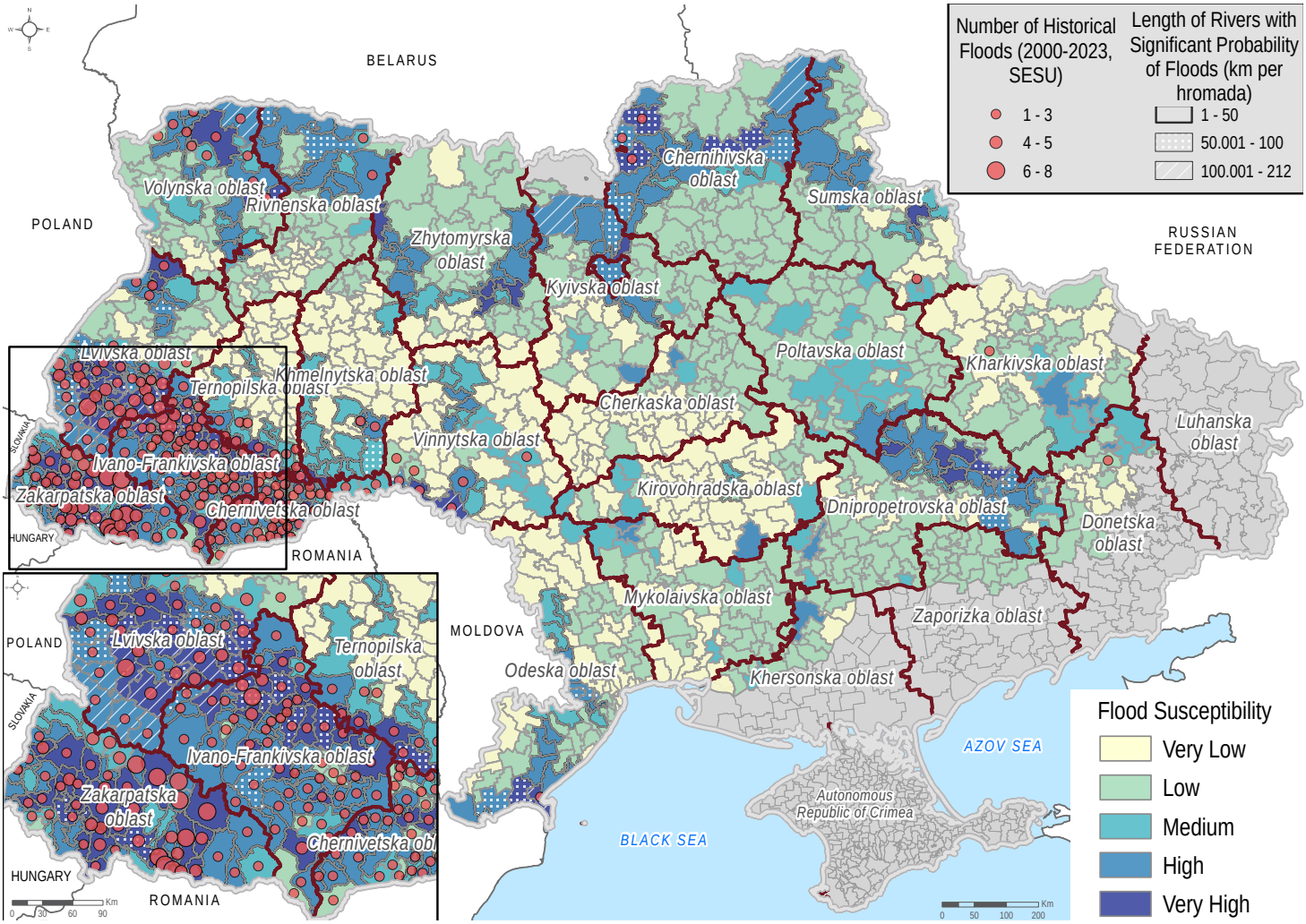
This dynamic is apparent in global policies and frameworks, where some countries and international organisations involved in DRM have resisted touching on conflict aspects. For example, the negotiations leading to the development of Sendai Framework for Disaster Risk Reduction 2015-2030 revealed issues with the inclusion of "conflict" in the final version.[34] Nonetheless, while explicit references to conflict are not apparent in the final text, the Sendai Framework's holistic approach highlights the importance of addressing conflict-related risks within the broader context of DRM and resilience-building. The implementation of the Sendai Framework is meant to be context-specific, allowing countries to adapt its principles to their unique challenges, which may include the integration of conflict considerations where relevant.[35]

Assessing flood risk in Ukraine

Flood risk levels were determined using a combination of hazard exposure, people's susceptibility, and lack of coping capacities (LOCC). This section explores these components to enable an understanding of the various components of risk, and their implications for DRM activities in the context of conflict.

Flood susceptibility

Approximately 27% of Ukraine's territory is susceptible to flooding. Flood risk is not even throughout the country and varies according to elevation, geomorphological features, local climatological patterns, and river basin's geographies. For example, only certain regions experienced unusually high river levels in 2022-23, due to an atypical pattern of heavy rainfall in winter and spring followed by rapid snowmelt.[36] These conditions resulted in extended flooding periods, including during winter months, predominantly affecting the northern part of the country.[37] Illustrating a different scenario, in 2023 intense summer rainfalls caused flooding in Western Ukraine, causing evacuations and significant damage to hundreds of homes in the town of Skhidnytsia.[38]



Map 1. Flood susceptibility levels per hromada.

Map 1 illustrates flood susceptibility at the hromada level in areas under the control of the GoU. This level was calculated combining geomorphological and hydrometeorological factors (e.g. land cover, elevation, rain duration) combined with incidence of historical floods and flood probability. Despite being split almost in half by the Dnipro River, one of the major transboundary rivers of Europe, the map shows that areas with the highest levels of flood exposure are located not near the Dnipro, but in the West and, to a lesser extent, in the North.

Western Ukraine is home to part of the Carpathian Mountains, whose complex and steep geography significantly differs from the rest of the country's flatlands. These features, in combination climate change-driven hydrometeorological disturbances, explain its high flood susceptibility, as observed during the June 2023 floods.[39]

"Development of action plans for adaptation to climate change is necessary to mitigate and effectively prepare for the catastrophic floods, especially in the Carpathians"
- KI from the Global Water Partnership in Ukraine.

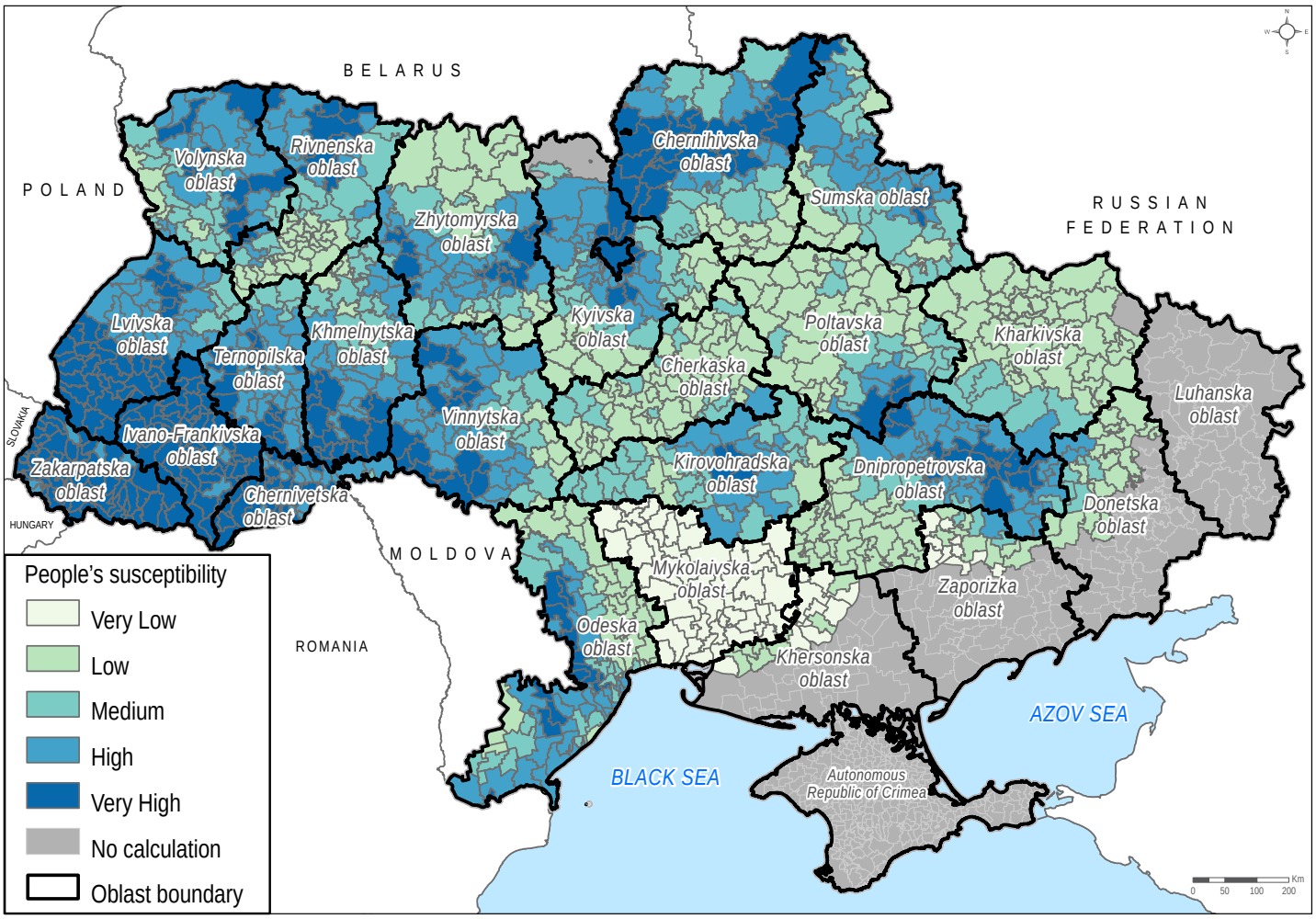
People's susceptibility to flooding

Flood susceptibility is not the only factor influencing flood risk, but rather a combination with vulnerability. For this assessment, the vulnerability level is calculated combining people's susceptibility and their LOCC – as illustrated in Diagram 1 in the methodology section. The following map presents the calculated people's susceptibility levels per hromada (see the Annex for calculation explanations).

Along with the hromadas most exposed to flooding (Map 1), there is a large concentration of hromadas with high and very high levels of people's susceptibility in the same western and northern regions of Ukraine (Map 2). Additionally, there are smaller concentrations of highly susceptible hromadas near the Black Sea and towards the Centre-East. This can be explained by the fact that people's susceptibility levels were calculated using not only population centers' proximity to flood-prone areas, but also the presence of internally displaced people (IDPs), young, and elderly populations.

Several KIs expressed that an option to reduce flood vulnerability could be by increased awareness on the flood-prone areas in the country through the development of local flood risk maps. This could guide local urban development plans and building codes that effectively integrate flood risks. However, KIs highlighted that the challenges posed by the war reduce the capacity of government institutions to implement such measures, particularly field work.

"Some of the works cannot be performed due to martial law, especially in the border area".
- KI from the State Emergency Service of Ukraine.



Map 2. People's susceptibility to flooding.

"We are not able to quickly perform some types of work due to lack of equipment and workers".
- KI from the Ukrainian Hydrometeorological Institute.

One KI highlighted the challenges associated with enforcing local flood risk maps restrictions, noting that enforcing restrictions on land use for building or farming in flood-prone areas lead to decreased income for residents or escalate the expenses associated with retrofitting homes with flood-protection features. As a solution, it was recommended to pair enforcement efforts with assistance programs. These programs would not only help mitigate the financial burdens but also raise awareness among the population about the risks associated with flood-prone areas.

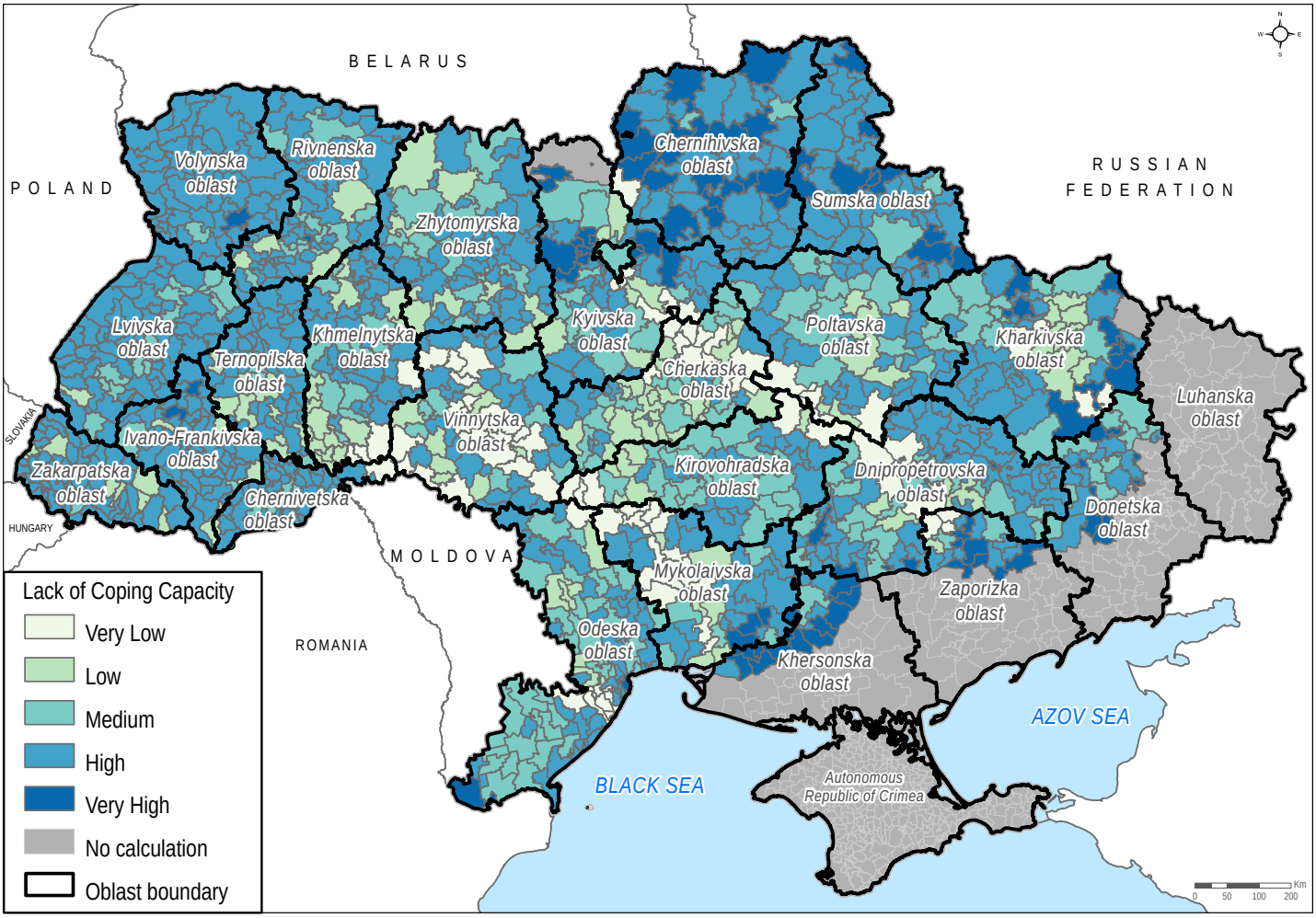
"Agricultural use of floodplains should be prohibited in regions that are at risk of flooding because it means money to people".
- KI from the WWF Ukraine.

Lack of coping capacities (LOCC)

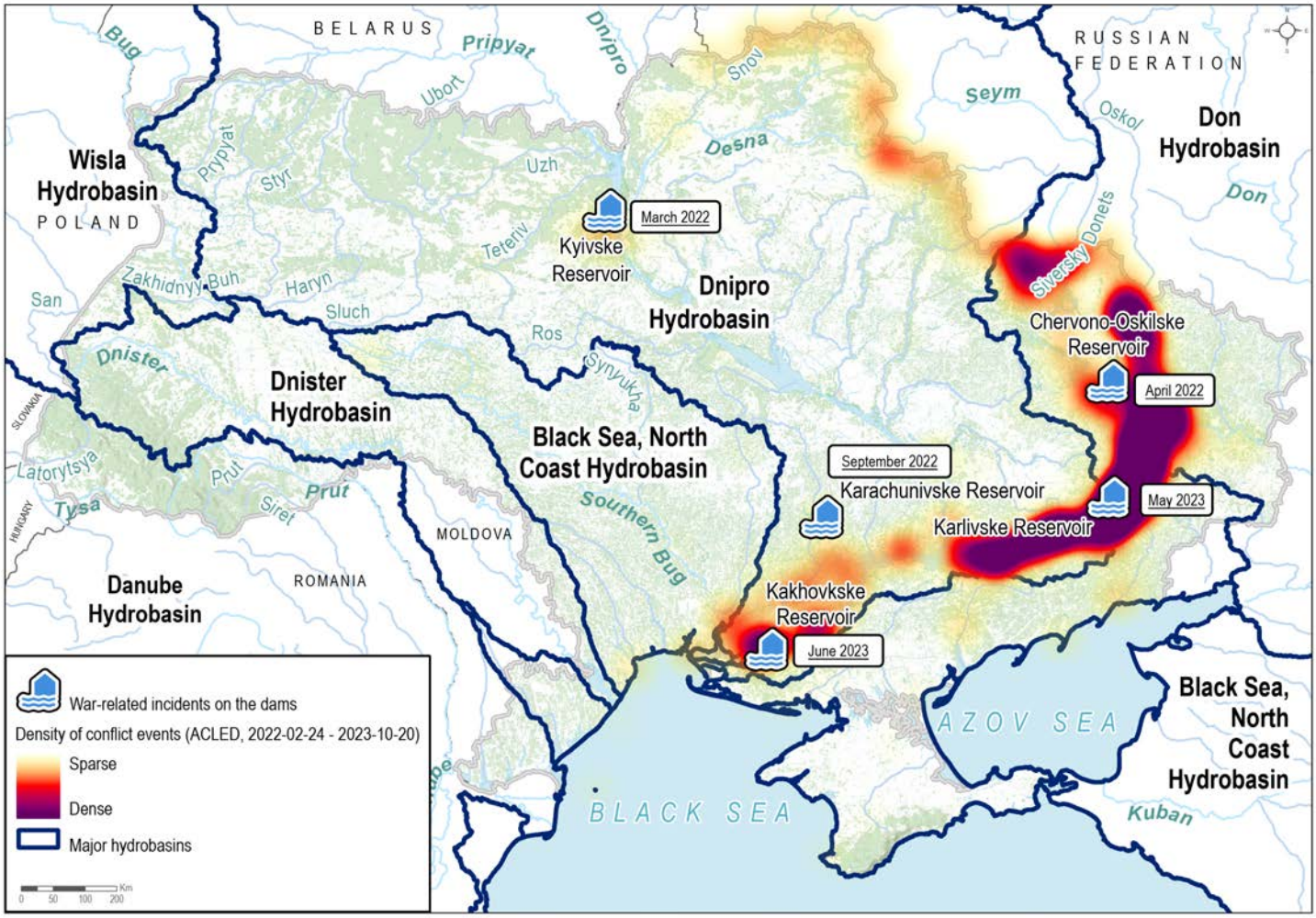
Vulnerability was also assessed considering the LOCC per hromada (shown in Map 3). For the purpose of this assessment, LOCC considers the availability of water-regulating facilities to mitigate flood risk, the density of war-related incidents, and risks of contamination due to conflict-related events to hazardous industrial facilities.[40] Contrarily to the flood exposure and people's susceptibility levels, most of the hromadas present medium and high LOCC levels, with very high-level hromadas in frontline areas bordering Russia and occupied territories (see Map 3). This concentration is caused by the intensity of the conflict in the East and South, which has resulted in large-scale damage and destruction of critical infrastructure.

"In our country, we are draining swamps, cutting down forests, extracting gravel and sand from riverbeds, and we cannot maintain the hydro-tehcnical infrastructure that we have created in proper condition".
- KI affiliated with the Ministry of Environmental Protection and Natural Resources of Ukraine.

Example of challenges associated with planning flood-protection measures
"In Lvivska oblast, polders were built to cut off the peaks of floods, but, unfortunately, they did not work because the rain fell on another territory".
- KI, former member of the Ministry of Environmental Protection and Natural Resources, and the State Agency of Water Resources of Ukraine.



Map 3. Lack of coping capacity levels per hromada.



Map 4. War-related incidents on the dams in Ukraine.

This damage has also impacted Ukraine's water management infrastructure. The collapse of the Nova Kakhovka Dam in June 2023 is an striking example, resulting in the flooding of 600 square km, casualties, mass evacuations, infrastructure damage, and potentially long-term environmental damage.[41] Map 4 presents the five water reservoirs whose dams have been affected during the hostilities. Most of them are in the East and South of the country, near the conflict's front line, with high density of conflict events localized in the East, matching the LOCC levels presented in Map 3.

KIs identified a critical need to rebuild or reinforce flood-protection mechanisms to reduce disaster risk. However, they stated that the war's cost has drained the country's budget, leaving little funding for infrastructure reparation.

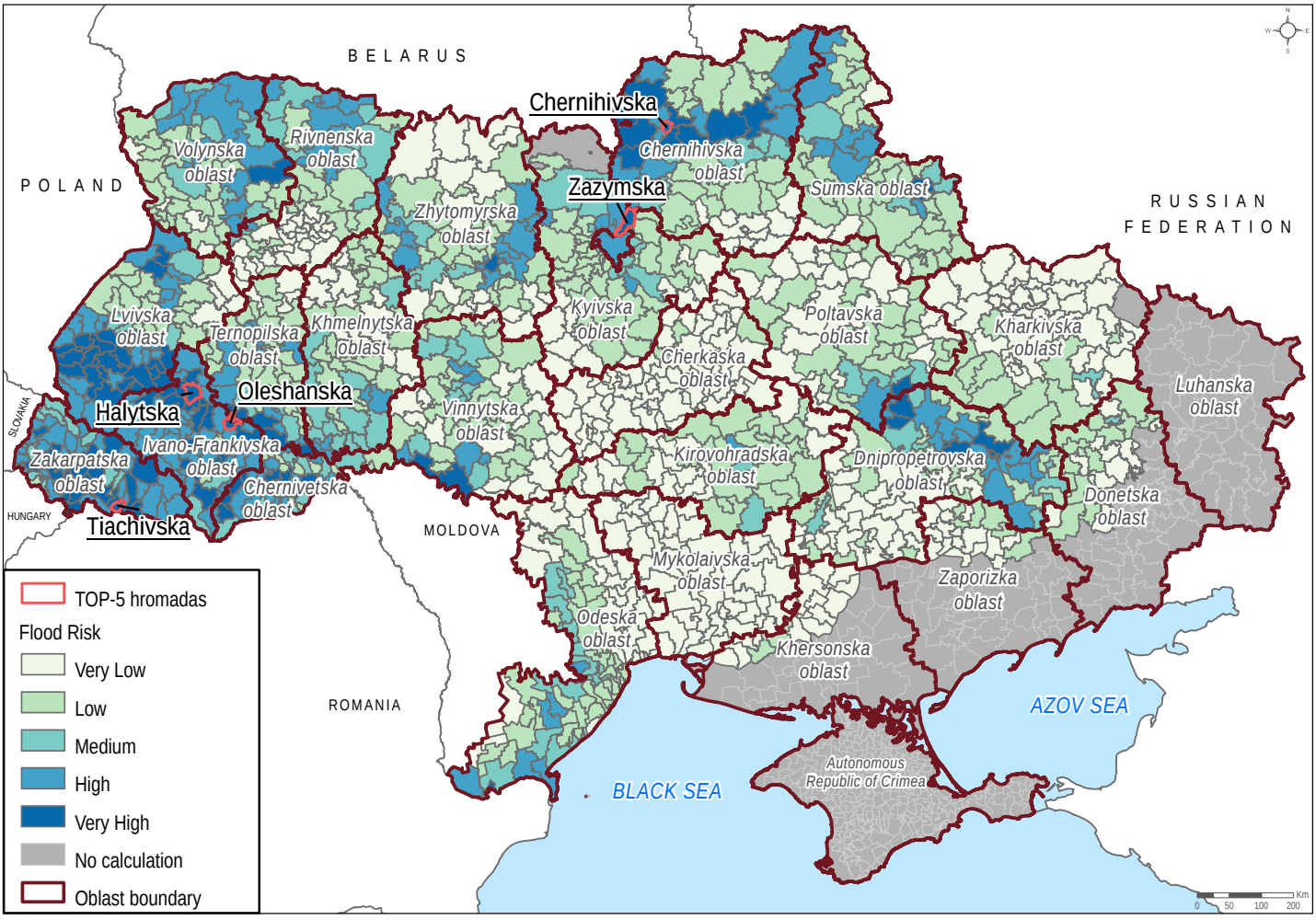
Flood risk level per hromada

After calculating the flood susceptibility level together with the vulnerability level (combining people's susceptibility and LOCC levels), shown in the maps 1 to 3, Map 5 provides the final results of the flood risk level per hromada. It highlights the top 5 hromadas with the highest flood risk level, being Halytska, Oleshanska and Tiachivska in the West, and Chernihivska and Zazymska in the North.

Hromadas identified as particularly vulnerable to flood hazards may require special attention from government and humanitarian actors to mitigate risks, improve preparedness at the community and systemic levels, and enhance emergency response. For instance, key informants have recommended establishing or strengthening multi-hazard early warning systems, which could be integrated with the existing air alert system. These efforts should be led by local governments according to the policy of Civil Protection of Ukraine, with support from international actors.

It is recommended to conduct further analysis of these critical hromadas to gain a detailed understanding of their risk levels and support the development of tailored flood management strategies.

Image 3. Collapsed bridge in Tiachivska, Zakarpatska oblast, due to flooding.



Map 5. Flood risk level per hromada, highlighting the top 5 hromadas with the highest flood risk levels.

Conclusion

This report analyses the multifaceted and overlapping challenges posed by flooding in Ukraine under the compounding pressures of the ongoing conflict. It underscores the need for targeted DRM strategies that not only address the immediate threats posed by natural hazards but also consider the exacerbated vulnerabilities caused by conflict. REACH's Flood Risk Index (FRI), which integrates variables pertaining to both flood hazard and conflict-driven vulnerabilities, supports the prioritisation of areas for conflict-sensitive DRM interventions by identifying hromadas with the highest levels of flood risks. This includes addressing the lack of coping capacities among Ukraine's populations, and the necessity to reinforce critical water management infrastructure and systems.

The adoption of comprehensive flood risk management strategies, aligned with European Union directives as part of Ukraine's broader integration efforts, marks a significant step towards mitigating the impacts of future flooding events. This strategic direction, supported by developing legal and policy frameworks, paves the way for a more resilient Ukraine that is better equipped to handle the dual challenges of natural hazards and conflict-induced vulnerabilities.

Tailored flood management and conflict-sensitive DRM measures remains critical in the context of the ongoing conflict. These efforts, coupled with enhanced international support and collaboration, are essential for building the resilience of Ukrainian communities and ensuring their safety and security in the face of increasing flood risks. The findings of this report can support humanitarian actors, government authorities, emergency responders and donors in guiding strategic planning and resource allocation in anticipation of the 2024 flood season in Ukraine.

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Annex - Methodology note

The calculation of riverine flood risk level across Ukraine employed various open geospatial datasets available both globally and nationally. While some of them were ready to use, others were used for extraction of necessary indicators, or had to be geo-coded to be suitable for processing in GIS. In general, flood risk is defined as the combination of hazard exposure (susceptibility) and vulnerability, while the latter is composed by people's general susceptibility and lack of coping capacities (LOCC). All the indicators used for estimating risk level were first aggregated at the hromada level by calculating the mean values for each of them. The indicators were then converted to relative values using the scale from 1 (lowest) to 5 (highest) by applying the "Jenks natural breaks optimization" algorithm.[42] The geographic scope of the analysis included 1,318 hromadas under control of the GoU as of November 2023, within 23 oblasts of Ukraine, excluding Luhanska and the Autonomous Republic of Crimea.

For estimation of the hazard exposure component, a standardised set of indicators have been used from similar assessments conducted by REACH in different national contexts.[43] However, to account for local environmental settings and triangulate results, three additional indicators were added for calculation of the flood hazard exposure. They included granular national data on recent historical floodings (2000-2023), length of river courses with significant risk (probability) of flooding officially defined by the State Emergency Services of Ukraine (SESU) in the Flood Risk Management Plans adopted in October 2022, and global data set on probable water levels for 100-year flood event developed by European Commission's Joint Research Centre (JRC).[44] Thus, the hazard exposure component was defined as a sum of the four mentioned above indicators with equal weights for each.

Vulnerability includes both people's susceptibility to be impacted by flooding and their LOCC, which might be decreased due to the protracted conflict. For each of the two components, four indicators were used. People's susceptibility component was the weighted sum of indicators such as numbers of IDPs in each hromadas, shares of elderly and younger population per hromada, and mean distance from settlements within hromada to flood-prone river courses. For the first three indicators, the weight was set at 0.5, while for the latter it was assigned as 1.

The LOCC component entailed the availability of water-regulating facilities to mitigate flood risks, density of war-related incidents, area contamination by explosive remnants of war (ERW) and incidents to hazardous facilities recorded from February 2022 to October 2023, provided by REACH's partner Zoi Environment Network under their joint Hazardous Events Monitoring Initiative. Since the primary focus of the assessment was flooding, for all indicators besides the first one, a weight of 0.5 was used and the weighted sum calculated similarly as for the susceptibility component.

Finally, all three components of flood risk were overlaid to calculate the hromada's "Flood Risk Index" (FRI) using the following formula.

$$\textbf{FRI} = \text{Hazard} \times \frac{(\text{Susceptibility} + \text{LOCC})}{2}$$

FRI values were then classified in five classes (from 'Very Low' to 'Very High') to rank hromadas accordingly.

In conjunction with the comprehensive FRI calculation, **nine key informant interviews were conducted with key stakeholders** from national entities specialising in water and environmental issues. These interviews allowed to enrich and contextualise the interpretation of FRI results and enhance design of in-deph area-based assessments in some of the flood hotspots.