Deliverable Phase 2 – Climate risk assessment

Evidence- driven climate risk adaptation measures for Bilhorod Dnistrovskyi (EDCRAMBD)

Bilhorod Dnistrovskyi, Odesa Oblast, Ukraine

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Document Information

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Brief Description	Refined regional/local climate risk assessment for Bilhorod-Dnistrovskyi, including updated heatwave and heavy rainfall analysis, comparison with Phase 1 results, interpretation of key risks, and preparation of inputs for Phase 3 adaptation strategies and risk management planning.
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Abbreviations and acronyms

Abbreviation / acronym	Description
CINEA	European Climate, Infrastructure and Environment Executive Agency
CLIMAAX	CLIMAte risk and vulnerability Assessment framework and toolboX
CRA	Climate Risk Assessment
EDCRAMBD	Evidence-driven climate risk adaptation measures for Bilhorod-Dnistrovskyi
EU	European Union
EURO-CORDEX	European Coordinated Regional Climate Downscaling Experiment
EuroHEAT	European heatwave assessment methodology
FSTP	Financial Support to Third Parties
GIS	Geographic Information System
IDPs	Internally Displaced Persons
INGO	International Non-Governmental Organisation
LAB	Laboratory, as used in Open Data LAB and Bankability LAB
N/A	Not applicable
NGO / NGOs	Non-Governmental Organisation / Non-Governmental Organisations
PU	Public dissemination level
R	Report
RCP	Representative Concentration Pathway
Tmax	Maximum daily temperature
Tmin	Minimum night temperature
USAID	United States Agency for International Development
WMO	World Meteorological Organization
XCLIM	Climate indices tool used for the heatwave analysis

Executive summary

This deliverable presents the Phase 2 Climate Risk Assessment for Bilhorod-Dnistrovskyi under the project Evidence-driven climate risk adaptation measures for Bilhorod-Dnistrovskyi (EDCRAMBD). It was developed to refine the Phase 1 assessment, compare the updated results with the initial findings, and provide a clearer basis for local climate risk management and adaptation planning.

Phase 2 confirms that the two priority climate risks for Bilhorod-Dnistrovskyi remain heavy rainfall / flash flooding and heatwaves. These risks are directly relevant to the municipality because they affect roads, drainage systems, public buildings, transport movement, exposed residential areas, public health, vulnerable groups and the Dniester Estuary.

The main added value of Phase 2 is the deeper and more localised interpretation of the risks. For heatwaves, the assessment was strengthened through an additional XCLIM-based analysis using locally adapted thresholds: daytime maximum temperature above 31.5°C, night minimum temperature above 15°C, and a minimum duration of five consecutive days. This additional method provides stronger local evidence than the standard workflow alone.

The XCLIM results show a clear increase in future heatwave risk. In the historical reference period 1971–1990, the assessment identified 15 heatwave days in total, equal to 0.75 heatwave days per year. For the future period 2056–2060, the projected number of heatwave days increases to 38 days under RCP4.5 and 41 days under RCP8.5. This confirms that heatwaves should be treated as a growing risk for public health, social infrastructure, urban greenery and public space planning.

For heavy rainfall / flash flooding, Phase 2 confirms the relevance of the Phase 1 findings. The assessment uses the thresholds of 100 mm in 24 hours for heavy rain and 90 mm in 3 hours for heavy showers. The results show that intense rainfall remains a serious risk, especially because of the limited stormwater drainage capacity, repeated street flooding, exposed infrastructure and the discharge of untreated runoff into the Dniester Estuary.

Stakeholder engagement during Phase 2 helped validate the technical findings. Local meetings held on 15 January 2026 and 6 May 2026 confirmed that flash flooding is perceived as the most visible and disruptive current climate risk. The discussions also strengthened attention to heatwaves, especially for elderly people, young children, schools, kindergartens, healthcare facilities, open-air markets and transport hubs.

The key risk assessment concludes that heavy rainfall / flash flooding is the highest priority risk and requires immediate action. Its current severity is substantial, future severity may become critical, and the municipality's resilience capacity is low to medium. Heatwaves are assessed as a high and increasing priority risk. They are currently less visible than flooding, but projections show a strong increase, and heat-risk reduction is not yet systematically integrated into local planning.

Several limitations remain. The main constraint is the lack of detailed local data, especially on drainage capacity, flood-prone streets, infrastructure condition, past damage, vulnerable households, tree cover and cooling access. Because of this, Phase 2 provides a strategic risk assessment, but not a full street-level flood model or engineering design.

The main conclusion is that Bilhorod-Dnistrovskyi should move from reactive responses to structured adaptation planning. Phase 3 should use the results of this deliverable to prepare the Local Climate Risk Management Plan, sectoral Adaptation Strategies, and bankable project ideas. The immediate focus should be stormwater management and flash flood resilience, while heatwave adaptation should be integrated into urban planning, public health, greenery and protection of vulnerable groups.

1 Introduction

1.1 Background

Bilhorod-Dnistrovskyi is a municipality in Odesa Oblast, southern Ukraine, located on the right bank of the Dniester Estuary, approximately 20 km from the Black Sea and 80 km from the city of Odesa. Historically known as Akkerman, the city has an important local and regional role due to its port-related activities, transport connections, public services, tourism potential and surrounding natural environment. The municipality is responsible for essential urban services, including local infrastructure, transport, utilities, waste management, education, healthcare and social welfare.

The community is increasingly exposed to climate-related hazards that affect public infrastructure, municipal services, ecosystems and residents' wellbeing. The most relevant hazards identified for the local climate risk assessment are heavy rainfall and heatwaves. Heavy rainfall events are particularly important because the existing stormwater drainage system has limited capacity. During intense rainfall, water accumulates on roads and in low-lying areas, disrupting transport, damaging public and private property, increasing erosion and landslide risks, and contributing to the discharge of untreated stormwater into the Dniester Estuary. This has environmental consequences for water quality, fish stocks and the wider ecosystem.

Heatwaves are also becoming increasingly relevant for Bilhorod-Dnistrovskyi. The municipality is located in southern Ukraine, where warm and dry conditions are characteristic of the region. Rising temperatures and more frequent periods of extreme heat may increase health risks, especially for vulnerable population groups such as elderly people, young children, people with chronic diseases and people spending time outdoors. Urban areas with limited tree cover, large paved surfaces, industrial land and exposed public spaces may experience stronger heat stress.

The first phase of the CLIMAAX project established the initial climate risk assessment framework for Bilhorod-Dnistrovskyi and selected the main hazards for further analysis. Phase 2 builds on this work by refining the assessment, deepening the interpretation of results and comparing new findings with the results of Phase 1. The purpose is to provide a stronger evidence base for the next stage of the project: the preparation of local climate risk management and adaptation planning measures.

1.2 Main objectives of the project

The overall objective of the project is to support Bilhorod-Dnistrovskyi in moving from reactive, short-term responses to climate-related events towards proactive, evidence-based and long-term climate adaptation planning. The project aims to establish a common framework for climate risk-related data, develop a standardised climate risk assessment, improve understanding of local vulnerabilities, and support the identification of future climate adaptation measures and funding opportunities.

The specific objective of Phase 2 is to refine the regional and local climate risk assessment by using the CLIMAAX Handbook, CLIMAAX workflows, available climate datasets and relevant local information. Compared with Phase 1, this deliverable focuses more strongly on the interpretation of results and on the added value of localising the assessment. Phase 2 confirms the relevance of the two selected hazards — heatwaves and heavy rainfall — and further develops the analysis by integrating additional methodological detail, including a locally adapted heatwave assessment.

The use of the CLIMAAX Handbook is important because it provides a transparent and harmonised structure for climate risk assessment. It helps organise the work according to clear steps: scoping, risk exploration, risk analysis, key risk assessment findings, monitoring and evaluation, and preparation for the next phase. This makes the assessment easier to understand, compare and update. It also helps connect technical results with practical decisions that the municipality will need to take in relation to infrastructure, public health, water management, emergency preparedness and environmental protection.

The inclusion of local data and local knowledge is particularly important in Phase 2. European and global datasets provide a useful basis for climate risk assessment, but they do not always reflect the specific conditions of Bilhorod-Dnistrovskyi, especially at municipal scale. Local information on affected areas, vulnerable public infrastructure, social facilities, transport nodes and previous flood impacts helps interpret the results in a more practical way. At the same time, the assessment identifies remaining data gaps, including limited access to detailed local meteorological data, drainage-system data and spatially explicit information on vulnerable population groups. These limitations are important for defining the work to be continued in Phase 3.

The results of Phase 2 are intended to support the preparation of Local Climate Risk Management Plans and Adaptation Strategies. They will help the municipality identify priority risks, define adaptation needs and prepare future projects related to stormwater management, flood mitigation, heat-risk reduction, green infrastructure, protection of vulnerable groups and environmental protection of the Dniester Estuary.

1.3 Project team

The project is led by Bilhorod-Dnistrovskyi City Council, which is responsible for overall project coordination, local data collection, administrative implementation and communication with relevant stakeholders. The municipal team includes representatives of the Department of Economy and Infrastructure Development, the Tourism and International Relations Division, the Accounting and Finance Department, and other relevant municipal units involved in local development, infrastructure and programme implementation.

The technical climate risk assessment work is supported by Anatoliy Smaliychuk from Ivan Franko National University of Lviv, who contributed to the preparation and interpretation of the climate hazard and risk analysis. External support is also provided by the Development Policy Foundation, including assistance with project coordination, reporting, review of deliverable structure, and alignment of the assessment with the overall CLIMAAX project requirements. The project also benefits from available inputs from national and external experts in climate, environment, GIS, sustainable development and funding preparation.

1.4 Outline of the document’s structure

This deliverable is organised according to the CLIMAAX Phase 2 reporting structure. Section 1 introduces the region, the purpose of the project, the objectives of Phase 2 and the project team. Section 2 presents the Phase 2 climate risk assessment, following the CLIMAAX framework. It covers scoping, risk exploration, scenario selection, regionalised risk analysis, key risk assessment findings, monitoring and evaluation, and the work plan for Phase 3.

Section 3 summarises the main conclusions of the Phase 2 climate risk assessment. Section 4 presents the progress evaluation and explains how the work carried out in Phase 2 contributes to the next stage of the project. Section 5 lists supporting documentation and additional materials used for the assessment. Section 6 provides the references and data sources used in the report.

2 Climate risk assessment – phase 2

2.1 Scoping

The scoping phase defines the purpose, boundaries, stakeholders and practical use of the climate risk assessment for Bilhorod-Dnistrovskyi. In Phase 1, the scoping work identified the main climate-related risks relevant for the municipality and confirmed the need to focus on heavy rainfall and heatwaves. Phase 2 builds on that initial work by refining the assessment, adding more locally adapted analysis where possible, and preparing the evidence base for the next phase of the project: local climate risk management and adaptation planning.

2.1.1 Objectives

The objective of the climate risk assessment is to provide Bilhorod-Dnistrovskyi Municipality with a clearer and more evidence-based understanding of its exposure and vulnerability to climate-related hazards, especially heavy rainfall and heatwaves. The purpose is not only to describe the hazards, but also to support practical decision-making by identifying which risks are most relevant for municipal planning, infrastructure management, public health, emergency preparedness and environmental protection.

The expected outcome of the climate risk assessment is a structured and comparable evidence base that can support the preparation of Local Climate Risk Management Plans and Adaptation Strategies. The assessment is intended to help the municipality move from reactive and short-term responses, such as emergency water pumping and road repair after heavy rainfall events, towards more proactive and long-term adaptation planning. The project results can inform future local and regional planning documents, including infrastructure development plans, stormwater management priorities, greenery and public space planning, emergency preparedness measures, and future applications for national, EU and international funding.

Compared with Phase 1, Phase 2 has a more specific objective: to refine the regional and local risk analysis and compare the updated findings with the preliminary results of the first deliverable. The main added value of Phase 2 is the deeper analysis of heatwave risk through an additional locally adapted method, as well as a clearer interpretation of the heavy rainfall results in relation to the local context. This helps translate technical climate information into practical messages for municipal decision-makers and other stakeholders.

The climate risk assessment is also expected to support the municipality in prioritising future adaptation interventions. For heavy rainfall, this includes stormwater drainage improvements, identification of flood-prone streets and transport nodes, protection of critical public infrastructure, erosion and landslide prevention, and reduction of polluted runoff into the Dniester Estuary. For heatwaves, this includes heat-risk reduction measures for vulnerable population groups, public facilities, schools, kindergartens, healthcare facilities, open-air markets and transport hubs.

The assessment has several limitations and boundaries. The most important limitation is the restricted availability of detailed local climate and impact data. Up-to-date local meteorological data for the municipality is not easily available in open sources, and the municipal government does not have regular access to detailed weather station data. Some local historical climate information is available for earlier periods, but it is not sufficient to fully quantify climate hazard changes at the desired level of detail. Therefore, the assessment relies partly on European and global datasets, including Copernicus Climate Data Store products, WorldPop and OpenStreetMap, combined with available local and municipal information.

Another limitation is the lack of detailed, spatially explicit local data on vulnerable groups, previous hazard impacts, exact flood locations, drainage-system capacity and infrastructure condition. This affects the possibility of producing a fully detailed, street-level flood risk model. The assessment therefore uses available open datasets and municipal knowledge as substitutes where direct local data is not available. This limitation is clearly acknowledged and should be addressed further in Phase 3 when the findings are translated into practical adaptation measures and project proposals.

Stakeholder involvement was also affected by the broader context of the ongoing war in Ukraine, limited institutional capacity and the pressure on local authorities to address urgent priorities. These conditions limited the extent to which broad participatory processes could be organised during Phase 2. To address this, the project focused on technical coordination with municipal representatives and experts, while planning wider use of the results in Phase 3 through adaptation planning, dissemination and the Bankability LAB.

2.1.2 Context

Until now, climate hazards and impacts in Bilhorod-Dnistrovskyi have mainly been handled through practical municipal response rather than through a comprehensive climate risk assessment system. Heavy rainfall and flooding have been recognised as recurring problems, especially where stormwater cannot be drained effectively. The municipality has relied on short-term measures such as water pumping, temporary repairs and local infrastructure interventions. These actions are necessary during emergencies, but they do not provide a long-term solution to increasing climate risks.

The problem addressed by the project is the gap between the growing climate-related risks faced by the municipality and the limited availability of structured local data, risk analysis and adaptation planning instruments. Heavy rainfall creates direct risks for roads, homes, public buildings, transport hubs, the sewage system and the Dniester Estuary. Heatwaves create risks for public health and wellbeing, especially in dense urban areas with limited tree cover and many paved or exposed surfaces. These risks are not isolated technical problems. They are connected to wider municipal development, environmental protection, public service delivery, infrastructure maintenance, social vulnerability and Ukraine's broader alignment with European climate and environmental standards.

The governance context is shaped by the responsibilities of Bilhorod-Dnistrovskyi City Council as the local authority responsible for municipal development, infrastructure, utilities, transport, waste management, education, healthcare and social welfare. The municipality has previous experience with climate-related planning, including the preparation of a Sustainable Energy and Climate Action Plan supported by USAID. However, available financial and technical resources remain limited, and the ongoing war has further reduced the capacity of local and national institutions to invest in climate resilience.

At regional and national level, the project is relevant because Ukrainian municipalities face similar challenges: ageing infrastructure, limited stormwater management capacity, insufficient local climate data, budget constraints and increasing exposure to extreme weather. The project can therefore provide a useful example of how a local authority can apply the CLIMAAX methodology to move towards more evidence-based climate adaptation planning.

Table 2.1.2- The most relevant sectors for the assessment

Sector	Climate relevance for Bilhorod-Dnistrovskyi
Urban infrastructure and roads	Heavy rainfall can flood streets, damage roads, interrupt transport and increase maintenance costs.
Water supply, sewage and stormwater management	Extreme rainfall can overload drainage and sewage systems and contribute to untreated runoff into the Dniester Estuary.
Public buildings and services	Schools, kindergartens, healthcare facilities and administrative buildings may be affected by flooding, heat stress or service interruption.
Public health and social welfare	Heatwaves increase health risks for elderly people, children and other vulnerable groups.
Transport and port-related activities	Flooded roads and transport hubs can disrupt local mobility, access to services and economic activity.
Environment and ecosystems	Untreated stormwater runoff affects the Dniester Estuary, water quality, fish stocks and ecosystem health.
Tourism and local economy	Flooding, heat stress and environmental degradation can reduce the attractiveness and resilience of the municipality.

Several external influences affect the climate risk assessment and future adaptation planning. The ongoing war in Ukraine creates financial, institutional and security constraints and makes long-term socio-economic projections more uncertain. At the same time, Ukraine's EU candidate status and future reconstruction process may create opportunities to mobilise external funding for climate resilience, infrastructure modernisation and environmental protection. The CLIMAAX project contributes to this context by helping the municipality prepare stronger evidence for future funding applications.

Possible adaptation interventions include improving stormwater drainage in flood-prone areas, developing nature-based solutions for runoff retention, increasing urban greenery and shading, improving maintenance of drainage channels, protecting critical public buildings, strengthening early warning and emergency response procedures, preparing heat-health guidance for vulnerable groups, improving public communication during extreme events, and developing bankable projects for external financing.

2.1.3 Participation and risk ownership

Stakeholder involvement in Phase 2 was organised through technical coordination with the municipal team, external experts and local stakeholders. The process focused on confirming the relevance of the selected hazards, reviewing available data and local knowledge, discussing exposed areas and vulnerable groups, and preparing the basis for Phase 3 adaptation planning.

During Phase 2, stakeholder participation was strengthened through two local stakeholder meetings organised in Bilhorod-Dnistrovskyi. The first meeting took place on 15 January 2026, and the second meeting took place on 6 May 2026. These meetings provided an opportunity to present the CLIMAAX project objectives, discuss the climate risks most relevant for the municipality, and collect local views on heavy rainfall, flash flooding, heatwaves, exposed infrastructure and vulnerable groups.

The meetings helped confirm that heavy rainfall / flash flooding and heatwaves remain the most relevant hazards for the local climate risk assessment. Stakeholders highlighted the practical consequences of heavy rainfall for roads, stormwater drainage, public buildings, transport movement, exposed residential areas and the Dniester Estuary. The discussions also supported the need to consider heat exposure in public spaces and around social infrastructure such as schools, kindergartens, healthcare facilities, open-air markets and passenger transport hubs.

The main stakeholders relevant to the project are Bilhorod-Dnistrovskyi City Council, municipal departments responsible for economy, infrastructure, utilities, international cooperation, finance, public services, education, healthcare and social welfare, local infrastructure and service providers, transport and port-related actors, local residents, vulnerable groups, environmental NGOs, researchers and external experts. The wider group of beneficiaries includes the population of Bilhorod-Dnistrovskyi, railway and seaport operators affected by flash flooding, environmental and climate researchers in Ukraine and the EU, and national, regional and local environmental organisations.

Risk ownership is organised primarily through the responsibilities of the local authority. Bilhorod-Dnistrovskyi City Council has the overall responsibility for local development, public infrastructure, municipal services, public communication and coordination of adaptation planning. However, the practical management of specific climate risks requires cooperation between several actors. Stormwater and road flooding risks relate mainly to infrastructure, utilities, road maintenance and emergency response functions. Heat-related risks relate to public health, social welfare, education, public space management and communication with vulnerable groups.

The stakeholder meetings also contributed to clarifying that climate risk management cannot be addressed by one institution alone. While Bilhorod-Dnistrovskyi City Council has the overall coordination role, practical risk reduction requires cooperation between municipal departments, public service providers, infrastructure and utility actors, community representatives, environmental stakeholders and external technical experts. This is particularly important for measures related to drainage improvement, maintenance of critical infrastructure, protection of vulnerable groups, public communication during extreme events and future investment planning.

Relevant vulnerable groups and exposed areas include elderly people, young children, people with health conditions, people living in flood-prone or poorly drained areas, users of schools, kindergartens and healthcare facilities, people using open-air markets and public transport hubs, and households located in areas with weak drainage or old building stock. Internally displaced persons may also be considered vulnerable, but the available information does not confirm the existence of an active collective IDP site within the assessed area. For this reason, IDPs are recognised as a potentially vulnerable group, but they were not mapped as a separate exposure layer in this phase.

Available information on acceptable or tolerable risk is limited. There is no formal local threshold defining what level of climate risk is acceptable for the municipality. However, based on past impacts and stakeholder discussions, repeated flooding of roads, disruption of transport, damage to public infrastructure, pollution of the Dniester Estuary and increasing heat exposure are not considered acceptable as long-term conditions. The purpose of the project is therefore to support the municipality in defining more concrete risk priorities and acceptable levels of risk during the preparation of the Local Climate Risk Management Plan and Adaptation Strategies in Phase 3.

2.1.4 Application of principles

The climate risk assessment applies the CLIMAAX principles of social justice, equity, inclusivity, quality, rigour, transparency and precaution.

Social justice, equity and inclusivity are addressed by focusing the assessment not only on physical hazards, but also on the people and places most likely to be affected. For the heatwave workflow, particular attention is given to children under five years old and elderly people aged 65 and above. Public facilities and places where vulnerable groups spend time, such as kindergartens, schools, healthcare facilities, open-air markets and transport hubs, are included in the exposure analysis. This helps ensure that adaptation planning considers social vulnerability and not only infrastructure damage.

Quality, rigour and transparency are addressed through the use of the CLIMAAX framework and documented datasets. The assessment explains which hazard, exposure and vulnerability data were used, including European climate datasets, Landsat-derived land surface temperature data, WorldPop demographic data, OpenStreetMap data and available local municipal information. The report also explains the limitations of the datasets, including moderate spatial resolution for some climate products and the absence of detailed local information on some exposure and vulnerability factors. This transparency is important for making the assessment understandable and reproducible.

The precautionary approach is applied because the available data is incomplete, but the risks are already visible and likely to increase under future climate scenarios. The lack of perfect local data is not treated as a reason to delay action. Instead, the assessment uses the best available evidence to identify priority risks and define where further data collection and adaptation planning are needed. This is especially important for heavy rainfall, where historical impacts already show that the municipality is vulnerable, even though high-resolution local flood modelling remains limited.

The application of these principles also supports the transition from technical risk assessment to practical adaptation planning. The results are intended to help the municipality prioritise measures that protect vulnerable people, reduce damage to critical infrastructure, improve environmental protection and support more resilient local development.

2.1.5 Stakeholder engagement

Stakeholder engagement during Phase 2 combined technical coordination with municipal representatives and external experts with two local stakeholder meetings held in Bilhorod-Dnistrovskyi on 15 January 2026 and 6 May 2026. The purpose of the engagement process was to confirm the relevance of the selected hazards, discuss the practical impacts of climate-related risks in the municipality, identify available local knowledge and data gaps, and prepare the basis for Phase 3 adaptation planning.

The participants included representatives of Bilhorod-Dnistrovskyi City Council and local stakeholders relevant to municipal development, infrastructure, public services, environmental protection and community resilience. External experts supporting the climate risk assessment also contributed to the interpretation of available data and the preparation of the Phase 2 analysis.

During the meetings, the project objectives and intermediate findings were presented in practical terms, with a focus on how the CLIMAAX climate risk assessment can support local decision-making. The discussions focused mainly on two priority hazards: heavy rainfall / flash flooding and heatwaves. Stakeholders discussed the effects of heavy rainfall on roads, stormwater drainage, public buildings, mobility, transport nodes, exposed residential areas and the Dniester Estuary. The meetings also helped raise attention to heat exposure in public spaces and around social infrastructure, including schools, kindergartens, healthcare facilities, open-air markets and passenger transport hubs.

The feedback received confirmed that the hazards selected in Phase 1 remain valid for the municipality. Heavy rainfall continues to be perceived as a priority risk because of its direct and visible impacts on infrastructure, mobility, public services and environmental quality. Heatwaves were also recognised as increasingly relevant, especially in dense urban areas with limited shading and for vulnerable population groups such as elderly people and young children.

The stakeholder discussions also confirmed that climate risk management cannot be addressed by one institution alone. Bilhorod-Dnistrovskyi City Council has the overall coordination role, but practical risk reduction requires cooperation between municipal departments, utility and infrastructure actors, public service institutions, community representatives, environmental stakeholders and external technical experts. This is particularly important for measures related to drainage improvement, maintenance of critical infrastructure, protection of vulnerable groups, public communication during extreme events and future investment planning.

The results and feedback from the stakeholder engagement process will be used in Phase 3 for the preparation of the Local Climate Risk Management Plan and Adaptation Strategies. They will help translate the technical results of the climate risk assessment into concrete adaptation priorities, including stormwater management, flood mitigation, heat-risk reduction, urban greenery and shading, protection of social infrastructure, environmental protection of the Dniester Estuary, and preparation of bankable projects for external funding.

The main difficulties encountered during stakeholder engagement were linked to the wider context of the ongoing war in Ukraine, limited institutional capacity, restricted availability of detailed local data, and the need to combine technical climate information with practical municipal planning needs. These limitations were addressed by using the CLIMAAX framework, combining available European and global datasets with local knowledge, and organising stakeholder meetings to validate the relevance of the results.

2.2 Risk Exploration

Screen risks (selection of main hazards)

- Bilhorod-Dnistrovska hromada (territorial community) being situated in the Southern Ukraine within steppe zone features warm and dry climate conditions. Amid mild weather conditions in winter climate-related hazards manifests usually during warm season. It includes heat waves and droughts associated with prolonged high air temperatures in the region which might abruptly change by rainfall events of extreme intensity. Historical records as well as future climate change projections suggest that these climate-related hazards will continue and intensify in future posing the main challenges towards climate-adapted and resilient future for this particular region.
- The latter may have as high magnitude as up to 300 mm per 12 hours which is about 70% of the annual precipitation volume calculated for historical climatic normal (1961-1990). Such events often lead to the massive crop loss, damage to residential buildings due to pluvial floods, especially flash and urban floods, interruption to traffic and infrastructure

facilities. Water supply and sewage system might be especially vulnerable to such extreme rainfalls due to the high wear and tear leading to street flooding, suspension in drinking water supply and excess contamination of surface water bodies as treatment plant capacity is exceeded. Usually households with poor or absent drainage systems are affected the most along with structures of Soviet period built without considering applying appropriate technologies for water protection.

- In contrast, to rainfall events steady increase in air temperatures lead to more frequent and pronged heat waves over the study region. Records on average monthly temperatures for 1961-1990 and 1981-2000 showed steady increase with new record high values observed for 10 out of 12 months over the year. Since assessed area is mainly represented by dense urban area, with high portion of industrial land and scarce tree vegetation, heat stress might be particularly severe impact on local population and their wellbeing. Drought usually accompanies the heat wave event, but in case of urban environment it is less relevant than for rural regions.
- Given the present and future climate conditions, environmental setting of the considered area the most relevant hazards to be included in risk assessment are heat wave and heavy rainfall.
- Up-to-date local weather and climate data for assessed municipality is hardly available in open source for Ukraine. There is weather station which is operated by State Hydrometeorological Center of Ukraine within municipality, but collected data are publicly available. Municipal government doesn't have access to this data neither on regular basis nor in case of the emergencies related to extreme weather conditions. However, there are some local data for the earlier periods 1961-1990 and 1981-2010 available. They provide insight into observed in-situ local climate conditions based on average and extreme (maximum and minimum) of average monthly air temperature and amount of precipitation. This data is not enough to reveal and quantify the changes in climate hazards in details, but some piece of information on that could be found in scientific papers and other official documents. Having access only fragmented to and generalized local climate data, using data sets available on Climate Data Store provided by Copernicus Climate Change Service is the only viable option.
- Detailed and spatially explicit information on population vulnerabilities (where does vulnerable population groups live/concentrate within hromada?), exposure to (where exactly impact of hazardous events were observed?), intensity and frequency of the climate-related hazardous events recorded in the area of interest might improve the hazard and risk assessment accuracy. But as for now such data is unavailable and might be substituted by using global open data sets needed for assessments (e.g., WorldPop, OpenStreetMap).

Workflow selection

Workflow #1 HEATWAVES

Vulnerable population used in this workflow included pre-school children (under 5 y.o.) and elderly people (65 y. o. and more) based on suggestion provided in workflow description. Particularly vulnerable to hazards of any nature are IDPs but neither INGO nor municipal government can confirm presence of working collective site for IDPs within assessed area. To define most exposed areas we used spatial data from open (OpenStreetMap) and official (Master Plan of Bilhorod-Dnistrovskyi city) sources on social infrastructure. It embraces schools, kindergartens, colleges, health care facilities, open air markets as well as key passenger transport hubs where citizens, and especially from vulnerable groups, spending time outside.

Workflow #2 HEAVY RAINS

For running this workflow threshold adapted from Ukrainian National Hydrometeorological Service for 'heavy rain' (100mm/ 24 h) and 'heavy shower' (90mm/ 3h) were used to define critical thresholds.

Choose Scenario

- For both selected workflows we used two climate change scenarios – RCP4.5 and RCP8.5. Given the high uncertainty present globally and low priority for climate change problem locally these scenarios looks as the most probable to happen. Both of these scenarios were considered at short (2026-2040), middle (2040-2070) and long-term (2080-2100) perspectives. Other nationwide or local socio-economic and population scenarios have not been considered due to the on-going war in the country which makes any predictions quire fuzzy. However, for the assessed municipality we expect preservation of current level or only slight decrease in population number. Depending on framework conditions in the country it may imply low-to-moderate economic development pace assuming graduate rise in energy consumption. Municipality has strong industrial sector, sea/river port and prominent tourist sights and is close to EU border which might secure its development in the future.

2.3 Risk Analysis

Workflow #1 HEATWAVES

Table 2.3.1 Data overview workflow #1

Hazard data	***Vulnerability data***	***Exposure data***	***Risk output***
Heatwave hazard assessment using EuroHEAT methodology Data set: *Heat waves and cold spells in Europe derived from climate projections* (12 x12 km gridded data for 1986-2085 under RCP4.5 and RCP8.5)	N/A	N/A	See the graph of heatwave occurrence in the future below
Heatwave hazard assessment using XCLIM methodology Data set: *Heat waves and cold spells in Europe derived from climate projections* (12 x12 km gridded data for 1971-2060 under	N/A	N/A	See the graphs of heatwave frequency and heatwave total duration

Hazard data	***Vulnerability data***	***Exposure data***	***Risk output***
RCP4.5 and RCP8.5)			
Risk assessment for heatwaves based on satellite-derived data Data set: Land surface temperature data from Landsat 8 for summer period (June-August) for 2023-2025 reclassified into five categories	Data from WordPop Hub on gender and age groups disstribution for Ukraine with 100 m spatial resolution as of 2020. Both male and female data sets were used for two wide age grops: 0-4 and ≥65 y.o.	Data from OpenStreetMap and Master Plan of Bilhorod-Dnistrovskyi city on social infrastructure available as building footprint for schools, kindergartens, colleges, health care facilities, open air markets and key passenger transport hubs	Heat risk level data as a raster image for target area (see image below)

Hazard assessment

Figure 2.3.1. EuroHEAT methodology

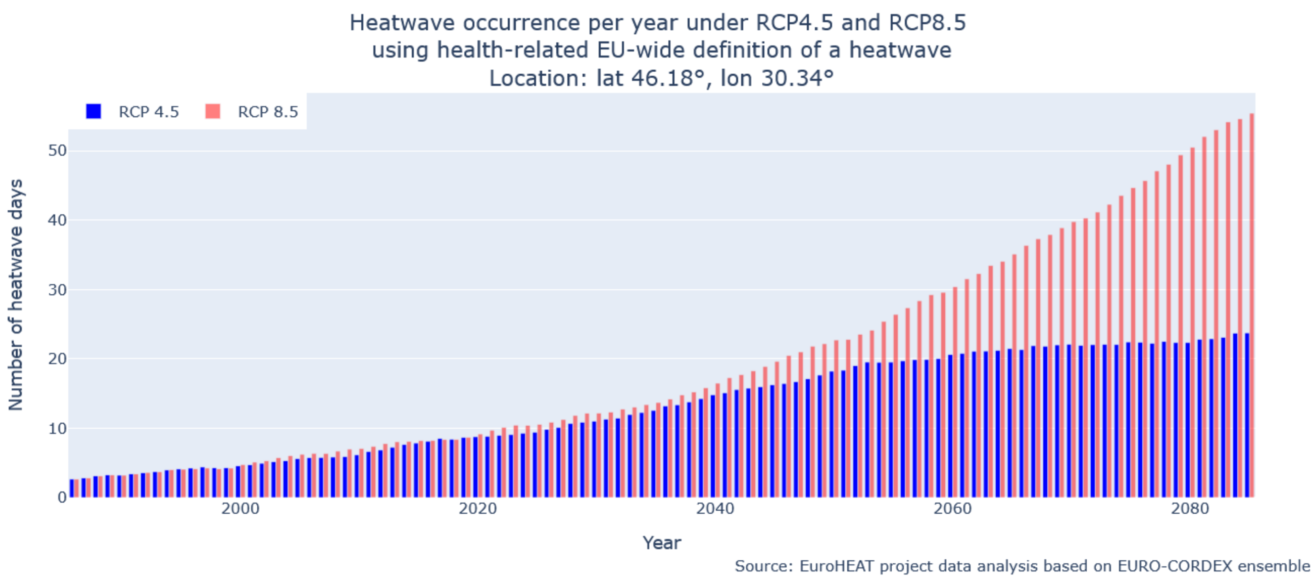
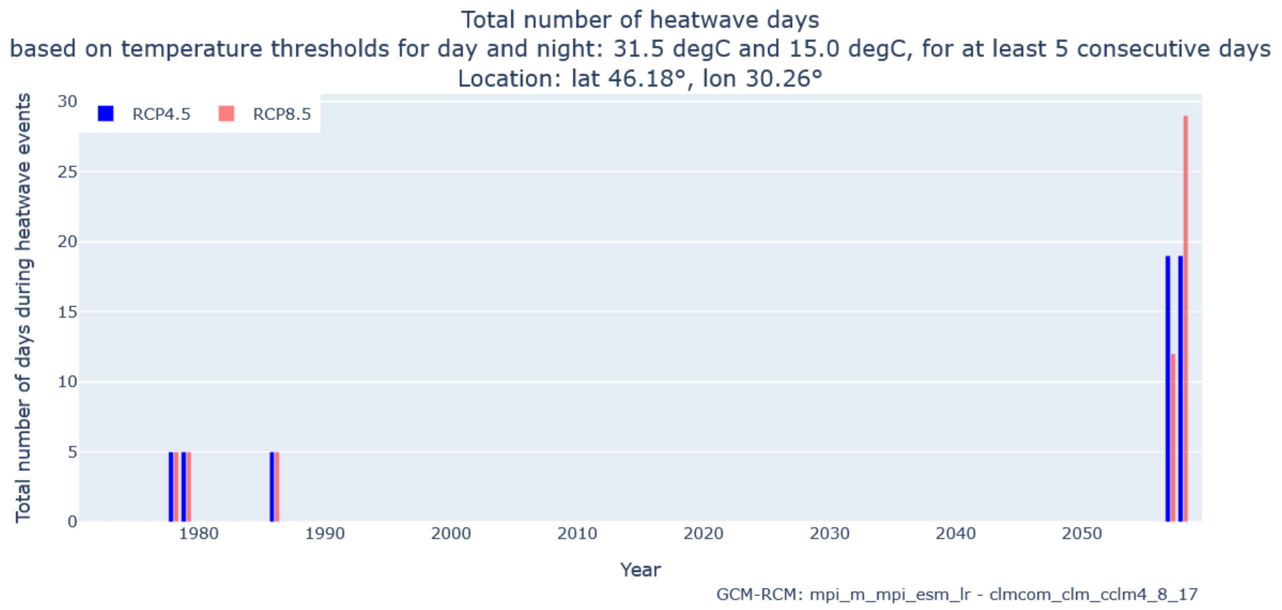


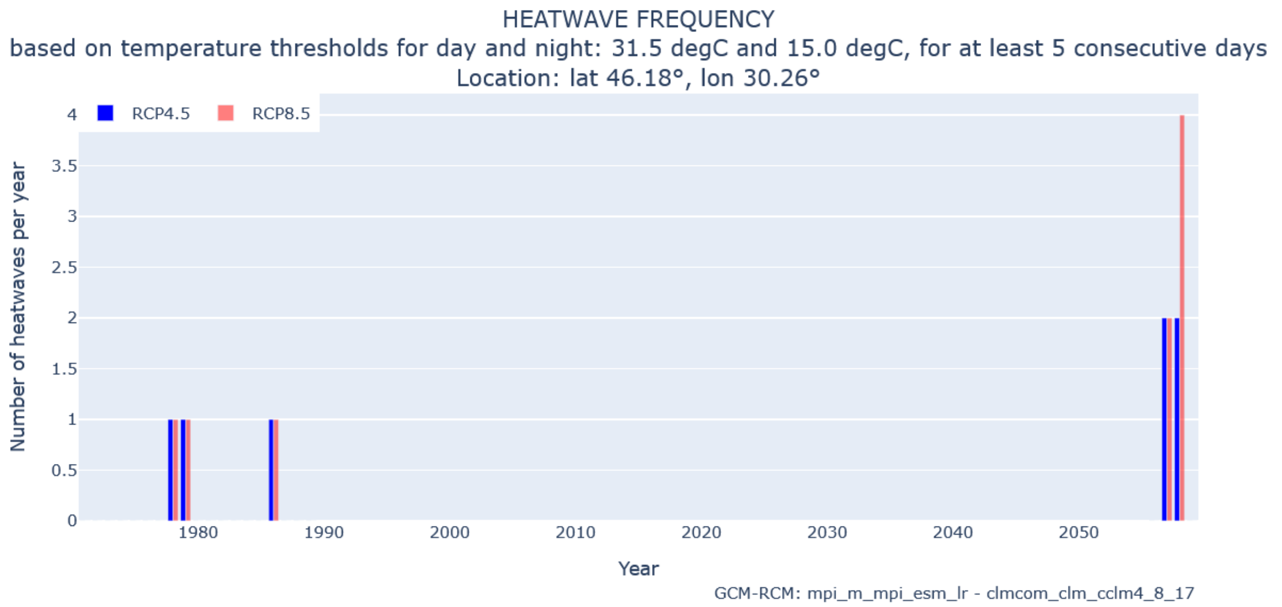
Table 2.3.1 Observed and projected heatwave occurrence based on EURO-CORDEX ensemble

Year	RCP4.5	RCP8.5
2000	4.6	4.8
2020	8.8	9.2

2030	11	12.2
2040	14.8	16.9
2050	18.2	22.7
2060	20.6	30.4
2070	22.1	39.8
2080	22.3	50.5

Figure 2.3.2. XClim methodology





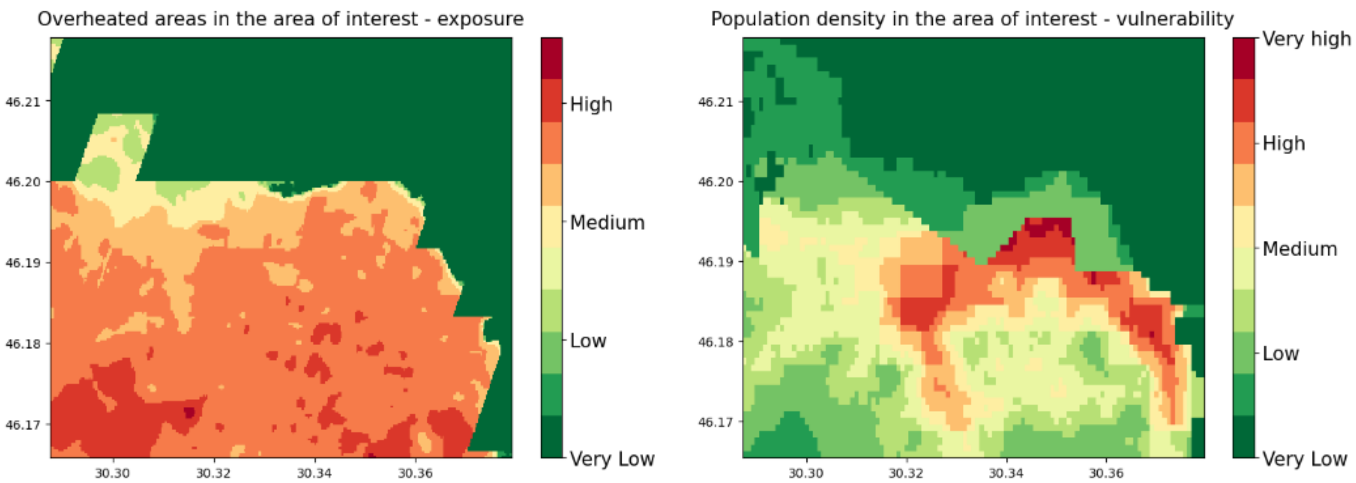
Observed and projected heatwave occurrence based on locally defined heatwave threshold of day Tmax 31.5°, night Tmin 15° C and duration of at least 5 consecutive days

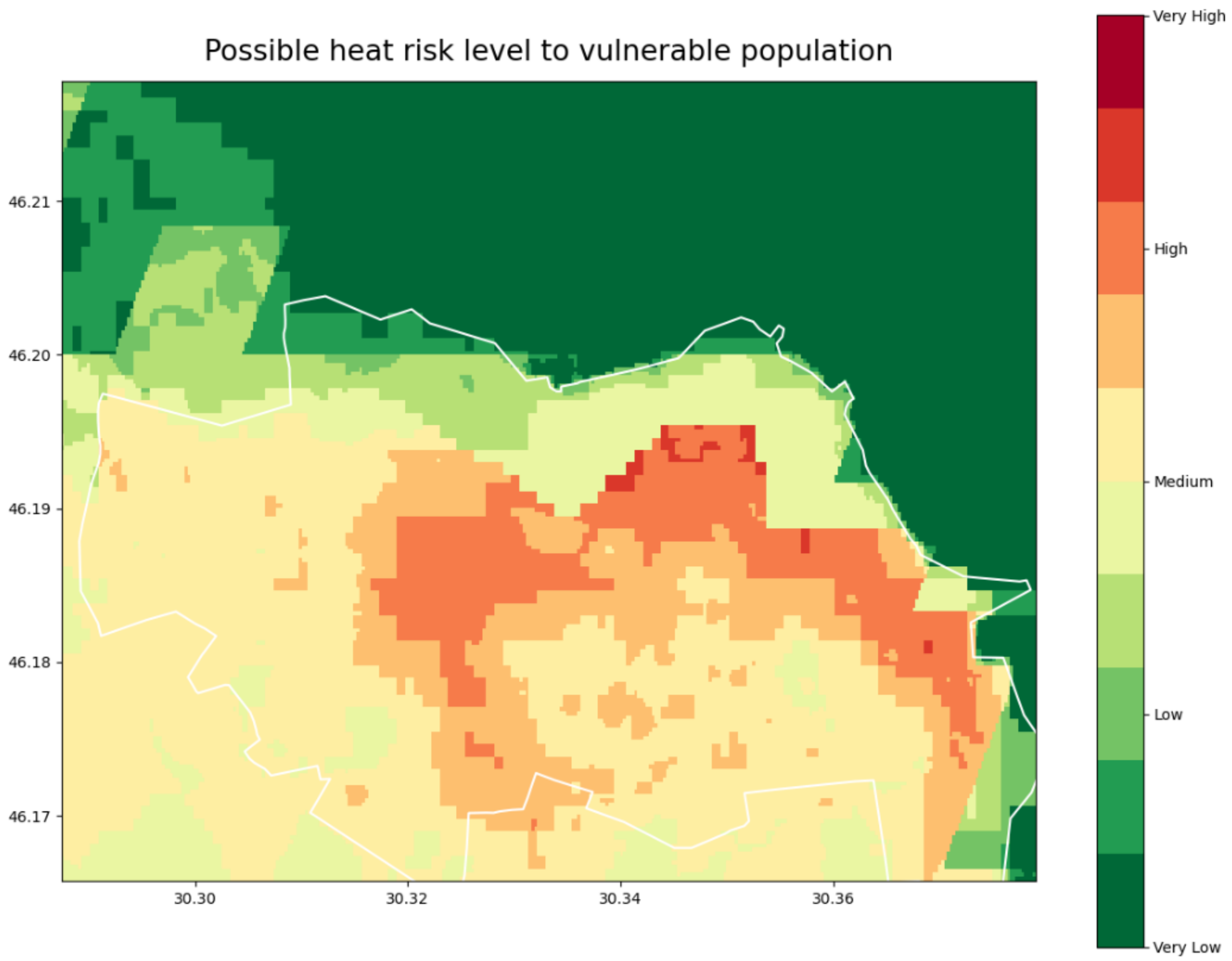
Table 2.3.2 Observed and projected heatwave occurrence based on locally defined heatwave threshold of day Tmax 31.5°, night Tmin 15° C and duration of at least 5 consecutive days

Time-frame	Emmision scenario	Total number of heatwave days observed/ projected over the period	Mean annual number of heatwave days observed/ projected	Maximum annual number of heatwave days observed/ projected	Mean annual heat-wave fre-quency	Maximum annual heat-wave fre-quency
1971-1990	N/A	15	0.75	5	0.15	1
2056-2060	RCP 4.5	38	7.6	19	0.8	2
2056-2060	RCP 8.5	41	8.2	29	1.2	4

Risk assessment

Figure 2.3.3 . Risk assessment





*Bilhorod-Dnistrovskyi hromada's boundary is showed in white line

Workflow #2 HEAVY RAINS

For this workflow ready-to-go pre-calculated European datasets (Path A) were used without need to run hazard assessment workflow as a separate step.

Table 2.3.2 Data overview workflow #2

Hazard data	***Vulnerability data***	***Exposure data***	***Risk output***
Historical precipitation data for 1976-2005 and duration of 3h and 24 h		Data from municipal government on the most affected areas in the past by heavy rains and associated flood events was provided.	
Projected precipitation data based on Global / Regional Climate Model Chain ichec-ec-earth / knmi_racmo22e			Information about projected change to the frequency and magnitude provided in the tables below

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
under two climate change scenarios RCP 4.5 and RCP 8.5 for three future time frames: 2011-2040, 2041-2070, 2071-2100			

Hazard assessment

For heat workflow using EUROHEAT methodology ready-to-go pre-calculated European datasets (Path A) were used without need to run hazard assessment workflow as a separate step.

For heat workflow using XCLIM methodology European datasets were used (Path B), but the local heatwave definition and appropriate threshold values were calculated and employed. Based on WMO heatwave definition and national publications (Shevchenko & Snizhko, 2012; Shevchenko O, 2010) the following criteria for definition of heatwave were used:

- monthly mean of the maximum day temperatures (Tmax) is at least 5° C above of the long term Tmax average for the reference period of 1961-1990. It this case it's equal 31.5° C.
- Minimum duration is 5 days.
- Minimum night temperature is not lower than 15° C. Hence, this criterion is absent in both of above mentioned publication it was introduced to exclude possible substantial cooling during the night hours.

To define temperature value for the first criterion for the city of Bilhorod-Dnistrovskyi we used data from Climate and Water Resources Atlas of Ukraine developed by Ukrainian Hydrometeorological institute. It allowed revealing the Tmax values for each of the summer months using which the mean summer value was calculated and then 5° C added. It resulted in a heatwave threshold of 31.5° C for the study area. To estimate historical pattern of heatwaves a 20-year period 1971-1990 was chosen while for future projections it was employed mid-term horizon of 2056-2060 under two emission scenarios: RCP 8.5 (high) and RCP 4.5 (moderate).

Risk assessment

For this risk assessment moderate resolution data of 12x12 km was used, therefore spatial explicit output (e.g. maps) for assessed location, i.e. Bilhorod-Dnistrovskyi municipality, is not expected.

Tables 2.3.3 **Projected change to precipitation under RCP 4.5 for 100 mm/ 24h rainfall events**

Input model parameters					Model output		
RCP	**Future horizon**	**Magnitude (mm)**	**Duration (h)**	**Frequency/return period (y)**	**Variation in magnitude if to maintain the same frequency/return period (%)**	**Projected return period if the magnitude remains the same (y)**	**Change of projected return period if the magnitude remains the same (%)**

4.5	2011-2040	100	24	5	18	3	-40
		100	24	10	19	6	-40
		100	24	50	20	26	-48
		100	24	100	20	51	-49
	2041-2070	100	24	5	8	4	-20
		100	24	10	12	7	-30
		100	24	50	22	27	-46
		100	24	100	26	48	-52
	2071-2100	100	24	5	21	4	-20
		100	24	10	31	6	-40
		100	24	50	55	15	-70
		100	24	100	66	26	-74

Projected change to precipitation under RCP 8.5 for 100 mm/ 24h rainfall events

Input model parameters					Model output		
RCP	**Future horizon**	**Magnitude (mm)**	**Duration (h)**	**Frequency/return period (y)**	**Variation in magnitude if to maintain the same frequency/return period (%)**	**Projected return period if the magnitude remains the same (y)**	**Change of projected return period if the magnitude remains the same (%)**
8.5	2011-2040	100	24	5	-10	9	80
		100	24	10	-14	22	120
		100	24	50	-21	151	202
		100	24	100	-24	357	257
	2041-2070	100	24	5	7	4	-20
		100	24	10	5	9	-10
		100	24	50	0	50	0
		100	24	100	-2	107	7
	2071-2100	100	24	5	18	3	-40
		100	24	10	15	6	-40
		100	24	50	7	37	-26
		100	24	100	4	83	-17

Projected change to precipitation under RCP 4.5 for 90 mm/ 3h rainfall events

Input model parameters					Model output		
RCP	**Future horizon**	**Magnitude (mm)**	**Duration (h)**	**Frequency/return period (y)**	**Variation in magnitude if to maintain the same frequency/return period (%)**	**Projected return period if the magnitude remains the same (y)**	**Change of projected return period if the magnitude remains the same (%)**
4.5	2011-2040	90	3	5	11	4	-20
		90	3	10	6	8	-20

		90	3	50	-5	61	22
		90	3	100	-9	147	47
	2041-2070	90	3	5	11	4	-20
		90	3	10	13	7	-30
		90	3	50	17	31	-38
		90	3	100	19	59	-41
	2071-2100	90	3	5	21	4	-20
		90	3	10	24	6	-40
		90	3	50	32	23	-54
		90	3	100	35	42	-58

Projected change to precipitation under RCP 8.5 for 90 mm/ 3h rainfall events

Input model parameters					Model output		
RCP	**Future horizon**	**Magnitude (mm)**	**Duration (h)**	**Frequency/return period (y)**	**Variation in magnitude if to maintain the same frequency/return period (%)**	**Projected return period if the magnitude remains the same (y)**	**Change of projected return period if the magnitude remains the same (%)**
8.5	2011-2040	90	3	5	-4	6	20
		90	3	10	-10	16	60
		90	3	50	-22	146	192
		90	3	100	-26	382	282
	2041-2070	90	3	5	13	4	-20
		90	3	10	7	8	-20
		90	3	50	-7	67	34
		90	3	100	-12	173	73
	2071-2100	90	3	5	28	3	-40
		90	3	10	28	5	-50
		90	3	50	28	23	-54
		90	3	100	28	45	-55

2.4 Key Risk Assessment Findings

The Key Risk Assessment step evaluates the outputs of the climate risk analysis by considering three main aspects: severity, urgency and capacity to respond. This step is important because it translates technical climate risk assessment results into practical priorities for municipal planning, stakeholder discussion and future adaptation measures.

In Phase 2, the key risk assessment focused on the two hazards selected in Phase 1 and confirmed through the refined assessment: heatwaves and heavy rainfall / flash flooding. This is consistent with the original project focus, which identified flash flooding, inadequate stormwater management, damage to roads and public infrastructure, and pollution of the Dniester Estuary as key climate-related problems for Bilhorod-Dnistrovskyi.

Compared with Phase 1, the main added value of Phase 2 is that the risk evaluation is based not only on the initial CLIMAAX workflow outputs, but also on additional expert analysis and local interpretation. In particular, the heatwave assessment was refined by Anatoliy Smaliychuk through the use of an additional XCLIM-based methodology. This method applied locally adapted heatwave thresholds for Bilhorod-Dnistrovskyi: daytime maximum temperature above 31.5°C, minimum night temperature above 15°C, and a minimum duration of five consecutive days. The historical reference period was 1971–1990, while the future period assessed was 2056–2060 under RCP4.5 and RCP8.5.

The XCLIM results strengthen the Phase 1 conclusion that heatwaves are an increasing climate risk for the municipality. In the historical reference period, the total number of heatwave days was 15, corresponding to an average of 0.75 heatwave days per year. For 2056–2060, the projected number of heatwave days increases to 38 days under RCP4.5 and 41 days under RCP8.5. The mean annual number of heatwave days rises to 7.6 under RCP4.5 and 8.2 under RCP8.5, while the maximum annual number reaches 19 days under RCP4.5 and 29 days under RCP8.5. This indicates that heatwaves are expected to become more frequent, longer and more relevant for public health and urban planning.

For heavy rainfall, Phase 2 confirms the relevance of the Phase 1 findings. The heavy rainfall workflow continued to use thresholds adapted from the Ukrainian hydrometeorological practice: 100 mm in 24 hours for heavy rain and 90 mm in 3 hours for heavy showers. The available model outputs show that such events may become more intense or more frequent under future climate scenarios, particularly in the medium and long term. However, due to the moderate spatial resolution of the available precipitation datasets, the Phase 2 analysis does not yet provide a detailed street-level flood model for Bilhorod-Dnistrovskyi. This limitation is important for the interpretation of the results and should be addressed in Phase 3 through local adaptation planning and, where possible, more detailed municipal drainage and impact data.

The Key Risk Assessment therefore combines four types of evidence:

Table 2.4 Types of evidence

Evidence used	Relevance for risk evaluation
Phase 1 CLIMAAX workflow outputs	Provided the initial hazard selection and preliminary risk assessment for heatwaves and heavy rainfall.
Phase 2 XCLIM heatwave analysis	Added a locally adapted method and confirmed a strong increase in future heatwave days.
Heavy rainfall threshold and projection analysis	Confirmed the continued relevance of extreme precipitation and flash flooding risk.
Stakeholder and expert feedback	Helped interpret technical results in relation to local infrastructure, vulnerable groups, municipal services and adaptation priorities.

Overall, the Phase 2 Key Risk Assessment confirms that heavy rainfall / flash flooding remains the most visible and immediately disruptive risk, while heatwaves represent a growing and increasingly important public health and urban resilience risk. These findings will guide the development of the Local Climate Risk Management Plan and Adaptation Strategies in Phase 3, with particular attention to stormwater management, protection of critical infrastructure, reduction of untreated runoff into the Dniester Estuary, heat-risk reduction, urban greenery, shading and protection of vulnerable groups.

2.4.1 Mode of engagement for participation

The risk evaluation process in Phase 2 combined technical expert assessment with stakeholder consultation. The technical component focused on interpreting the outputs of the heatwave and heavy rainfall workflows, including the additional XCLIM heatwave analysis prepared by Anatoliy Smaliychuk. The participatory component focused on checking whether the technical findings correspond to local experience, municipal priorities and stakeholder perceptions of climate risk.

Stakeholder engagement was carried out through two local stakeholder meetings held in Bilhorod-Dnistrovskyi on 15 January 2026 and 6 May 2026. These meetings were already described in Section 2.1.5. In the context of the Key Risk Assessment step, their main function was to support the interpretation of severity, urgency and capacity to respond for the two selected risks.

The meetings involved representatives of Bilhorod-Dnistrovskyi City Council and local stakeholders relevant to municipal development, infrastructure, public services, environmental protection and community resilience. External experts contributed to the interpretation of climate and geospatial data, including heatwave projections, land surface temperature patterns, heavy rainfall thresholds, exposed infrastructure and vulnerable population groups.

The feedback gathered during the engagement process confirmed that heavy rainfall / flash flooding is perceived locally as a high-priority risk. Stakeholders recognised that intense rainfall affects roads, stormwater drainage, transport movement, public buildings, residential areas and the Dniester Estuary. The discussions confirmed that this risk is not only a technical drainage issue, but also a broader municipal resilience issue affecting mobility, public service continuity, environmental quality and future investment needs.

Stakeholders also confirmed the increasing relevance of heatwaves. While heatwaves may be less immediately visible than flash flooding, the Phase 2 results show that they are expected to become significantly more frequent in the future. This was particularly important when discussing vulnerable groups and exposed locations, including elderly people, young children, schools, kindergartens, healthcare facilities, open-air markets, transport hubs and dense urban areas with limited shading or vegetation.

The XCLIM results helped strengthen the discussion on heatwave urgency. The increase from 15 heatwave days in the historical reference period to 38–41 heatwave days in the future period 2056–2060 shows that heatwaves should not be treated as a secondary issue. They need to be considered alongside flash flooding in the next phase of adaptation planning, especially for public health, social services, urban greenery and public space management.

The risk evaluation did not use a formal voting-based scoring workshop with all stakeholder groups. Instead, severity, urgency and capacity were assessed through a structured expert judgement process, supported by stakeholder feedback, available municipal knowledge and the Phase 2 technical results. This approach was considered appropriate because the municipality faces capacity constraints, limited access to detailed local data and the wider institutional pressure caused by the ongoing war in Ukraine.

The main feedback from the engagement process can be summarised as follows:

Table 2.4.1 Engagement process feedback

Risk	Feedback gathered during Phase 2 engagement	Implication for risk assessment
Heavy rainfall / flash flooding	Considered a current and visible problem affecting roads, drainage, transport, public buildings and the Dniester Estuary.	High severity and high urgency; immediate adaptation planning is needed.
Heatwaves	Recognised as an increasing risk, especially for vulnerable groups and exposed public spaces.	Growing severity and increasing urgency; should be integrated into urban planning, public health and greenery measures.
Data and capacity limitations	Stakeholders and experts confirmed that detailed local meteorological, drainage and vulnerability data remain limited.	Risk assessment should be updated in future phases as more local data becomes available.
Future use of results	Results should support practical adaptation measures and external funding applications.	Findings should feed directly into the Local Climate Risk Management Plan, Adaptation Strategies and Bankability LAB.

The engagement process confirmed that both selected hazards should remain priorities for Phase 3. Heavy rainfall / flash flooding requires immediate attention because of its direct impacts on infrastructure, transport and the environment. Heatwaves require stronger integration into local planning because the refined Phase 2 analysis shows a clear future increase in heatwave occurrence. The outcomes of the risk evaluation will therefore be used to define priority adaptation measures, identify responsible municipal actors and prepare bankable climate resilience projects.

2.4.2 Gather output from Risk Analysis step

The risk evaluation in Phase 2 uses the outputs generated in the Risk Analysis step for the two selected climate hazards: heatwaves and heavy rainfall / flash flooding. These outputs provide the evidence base for assessing severity, urgency and capacity to respond. Compared with Phase 1, the Phase 2 risk evaluation uses both the initial CLIMAAX workflow results and the refined analysis prepared during this phase, especially the additional locally adapted heatwave assessment.

The following outputs from the Risk Analysis step were used for the Key Risk Assessment:

Table 2.4.2 Risk Analysis step

Climate risk	Risk Analysis output used for evaluation	Relevance for Key Risk Assessment
Heatwaves	EuroHEAT-based heatwave occurrence projections using EURO-CORDEX ensemble data under RCP4.5 and RCP8.5	Used to assess the long-term increase in heatwave occurrence and compare future risk under different climate scenarios.
Heatwaves	XCLIM-based locally adapted heatwave analysis using Bilhorod-Dnistrovskyi-specific thresholds: Tmax above 31.5°C, Tmin above 15°C, minimum duration of five consecutive days	Used as the main Phase 2 refinement to assess how heatwaves may change under local climatic conditions.
Heatwaves	Historical heatwave baseline for 1971–1990 and future	Used to compare historical and

	heatwave projection for 2056–2060 under RCP4.5 and RCP8.5	future heatwave conditions and assess urgency.
Heatwaves	Land surface temperature analysis based on Landsat 8 summer data for 2023–2025, reclassified into five heat categories	Used to identify areas of higher local heat exposure within the municipality.
Heatwaves	Vulnerability data from WorldPop for children aged 0–4 and elderly people aged 65+, combined with social infrastructure data from OpenStreetMap and the Master Plan of Bilhorod-Dnistrovskyi	Used to assess who and which facilities are most exposed to heat risk.
Heavy rainfall / flash flooding	Heavy rainfall thresholds of 100 mm / 24 hours and 90 mm / 3 hours, adapted from Ukrainian hydrometeorological practice	Used to define critical rainfall events relevant for Bilhorod-Dnistrovskyi.
Heavy rainfall / flash flooding	Projected precipitation changes under RCP4.5 and RCP8.5 for short-, medium- and long-term horizons	Used to assess whether extreme rainfall events may become more frequent or more intense in the future.
Heavy rainfall / flash flooding	Municipal information on areas historically affected by heavy rainfall and associated flooding	Used to interpret model results in relation to known local impacts.
Heavy rainfall / flash flooding	Qualitative information on impacts on roads, stormwater drainage, transport hubs, public buildings, residential areas, landslide-prone areas and the Dniester Estuary	Used to assess severity and consequences for infrastructure, services and the environment.

For heatwaves, the most important Phase 2 output is the additional XCLIM analysis. This analysis shows a clear increase in heatwave occurrence compared with the historical reference period. In 1971–1990, the total number of heatwave days was 15, with a mean annual value of 0.75 heatwave days. For 2056–2060, the number of heatwave days increases to 38 days under RCP4.5 and 41 days under RCP8.5. The mean annual number of heatwave days rises to 7.6 under RCP4.5 and 8.2 under RCP8.5, while the maximum annual number reaches 19 days under RCP4.5 and 29 days under RCP8.5.

This output is important for risk evaluation because it confirms that heatwaves are not only a future climate trend but a relevant local risk for Bilhorod-Dnistrovskyi. The increase in heatwave days affects the severity and urgency scoring, especially because vulnerable groups such as elderly people and young children may be more sensitive to prolonged heat exposure. The combination of heat hazard data with land surface temperature, population vulnerability and social infrastructure data also helps identify where adaptation measures should be prioritised, including schools, kindergartens, healthcare facilities, open-air markets, passenger transport hubs and densely built areas with limited shading.

For heavy rainfall / flash flooding, the Risk Analysis step provides threshold-based precipitation outputs for 100 mm in 24 hours and 90 mm in 3 hours rainfall events. These thresholds are relevant for local risk evaluation because they correspond to events that can overload drainage systems, cause street flooding, block roads and transport hubs, damage public and private property, trigger erosion or landslides, and increase untreated runoff into the Dniester Estuary.

The heavy rainfall outputs were used mainly to evaluate the likelihood of future changes in intensity and frequency. The results indicate that extreme rainfall remains a relevant hazard under both RCP4.5 and RCP8.5, although the exact magnitude of change varies by scenario, time horizon and rainfall duration. Because the available precipitation data has moderate spatial resolution, the outputs are not sufficient to produce a detailed street-level flood model. Therefore, the risk evaluation combines the model results with municipal knowledge about historically affected areas and stakeholder feedback.

The Phase 2 risk evaluation therefore relies on both quantitative and qualitative outputs. Quantitative outputs are used to assess changes in heatwave days and projected precipitation characteristics. Qualitative and local outputs are used to interpret what these changes mean for municipal infrastructure, public services, vulnerable groups, the local economy and the environment.

Overall, the Risk Analysis outputs show that:

Heatwaves are projected to increase substantially and require stronger attention in public health, urban planning, greenery and social infrastructure protection.

Heavy rainfall / flash flooding remains the most visible and immediately disruptive risk for the municipality, especially because of the limited stormwater drainage capacity and known impacts on roads, transport, public buildings and the Dniester Estuary.

The results of Phase 2 confirm the Phase 1 hazard selection but provide a stronger basis for prioritisation, especially through the locally adapted XCLIM heatwave analysis and the clearer interpretation of heavy rainfall impacts.

The outputs are sufficient to support strategic risk prioritisation in Phase 3, but additional local data will be needed for detailed design of specific adaptation investments, especially drainage-system improvements and site-specific flood mitigation measures.

2.4.3 Assess Severity

Severity was assessed for the two selected climate risks: heavy rainfall / flash flooding and heatwaves. The assessment considered current impacts, historical experience, projected future changes, affected sectors, exposed infrastructure, vulnerable groups, possible cascading effects, and feedback received through stakeholder and expert engagement. The four severity categories used were: limited, moderate, substantial and critical.

Heavy rainfall / flash flooding

The current severity of heavy rainfall / flash flooding is assessed as substantial. This risk is already present in Bilhorod-Dnistrovskyi and has visible consequences for the municipality. Heavy rainfall events can overload the stormwater system, flood streets, block transport movement, damage homes, roads and public buildings, trigger erosion and landslides, and increase untreated stormwater discharge into the Dniester Estuary.

The project application identifies flooding as a recurring problem, with the August 2019 event used as a clear example: 120 mm of rain fell in only a few hours, causing widespread flooding, damage to homes, roads and public facilities, including the collapse of the Administrative Service Centre. The same source also highlights transport paralysis, traffic accidents, road damage, landslides, erosion and pollution of the Dniester Estuary as relevant consequences of heavy rainfall and insufficient drainage capacity.

The severity is assessed as substantial, rather than limited or moderate, because the impacts are not restricted to one location or one sector. Heavy rainfall affects transport, public infrastructure, residential areas, roads, sewage and stormwater systems, public safety, environmental quality and the local economy. The consequences can also be cascading. Blocked roads can delay emergency response and access to public services. Overloaded drainage can increase pollution. Repeated flood damage can increase maintenance costs and reduce the municipality's ability to invest in long-term resilience.

For the future period, the severity of heavy rainfall / flash flooding is assessed as critical. This is because the risk is already serious under current conditions, while the municipality has limited drainage capacity and limited financial and technical resources for large-scale infrastructure improvements. The heavy rainfall analysis confirms that extreme precipitation remains a relevant hazard under future climate scenarios. Even where the precise magnitude of change varies by scenario and time horizon, the combination of extreme rainfall, ageing infrastructure, insufficient stormwater management capacity and exposed urban areas means that future impacts could become more severe if adaptation measures are not implemented.

Stakeholder feedback strengthened this severity assessment. Participants in the Phase 2 meetings confirmed that heavy rainfall is perceived locally as the most visible and disruptive climate risk. Their perspective is important because it links the technical rainfall thresholds and model outputs with real local experience: flooded streets, blocked movement, damage to infrastructure and pollution of the Dniester Estuary. This confirms that the risk is not only theoretical or model-based, but already affects municipal functioning.

Decision-makers and municipal staff have practical knowledge of flood impacts and emergency responses, but further capacity-building is still needed to systematically interpret climate projections, risk maps and investment priorities. The CLIMAAX process therefore contributes to improving the understanding of risk severity and turning local experience into structured adaptation planning.

Heatwaves

The current severity of heatwaves is assessed as moderate to substantial. Heatwaves are less visibly disruptive than flash floods, but they are already relevant for Bilhorod-Dnistrovskyi because the municipality is located in southern Ukraine, has warm and dry summer conditions, and includes dense urban areas, industrial land, paved surfaces and places with limited tree cover. These conditions can increase heat stress, especially in public spaces and around social infrastructure.

The Phase 1 assessment already identified heatwaves as one of the main hazards for the municipality. It used satellite-derived land surface temperature data, WorldPop demographic data and social infrastructure information to identify heat-risk patterns. Vulnerable groups considered in the assessment included children under five and elderly people aged 65 and above. Exposed facilities included schools, kindergartens, healthcare facilities, open-air markets and key passenger transport hubs.

The Phase 2 XCLIM analysis prepared by Anatoliy Smaliychuk strengthens the severity assessment. Using locally adapted thresholds — daytime maximum temperature above 31.5°C, minimum night temperature above 15°C, and at least five consecutive days — the results show a clear increase in heatwave days. The historical reference period 1971–1990 recorded 15 heatwave days in total, while the future period 2056–2060 shows 38 heatwave days under RCP4.5 and 41 heatwave days under RCP8.5. The mean annual number of heatwave days increases from 0.75 historically to 7.6 under RCP4.5 and 8.2 under RCP8.5.

For the future period, the severity of heatwaves is assessed as substantial. The risk is not assessed as critical at this stage because the available analysis does not provide evidence of widespread direct mortality, large-scale economic loss or irreversible ecosystem destruction. However, the projected increase in heatwave occurrence is significant, and the consequences for public health, social services, schools, kindergartens, healthcare facilities and exposed public spaces may become serious if adaptation measures are not introduced.

The potential cascading effects of heatwaves include increased demand for healthcare services, higher pressure on elderly care and social support, reduced comfort and safety in public spaces, lower productivity for outdoor workers, higher energy demand for cooling, and increased stress on vulnerable residents. If heatwaves coincide with drought conditions or electricity supply constraints, the consequences could become more severe.

Stakeholder and expert discussions enriched the severity assessment by showing that heatwaves should not be treated as a secondary risk. While flash flooding remains the most visible hazard, heatwave exposure affects people differently and may be underestimated because its impacts are less immediate. The focus on vulnerable groups changed the perception of severity: for healthy adults the current risk may seem moderate, but for elderly people, young children and people using exposed public spaces, the risk is already more serious.

Overall, the severity assessment shows that heavy rainfall / flash flooding is currently the most severe risk, while heatwaves are a growing risk whose severity will increase substantially in the future.

2.4.4 Assess Urgency

Severity was assessed for the two selected climate risks: heavy rainfall / flash flooding and heatwaves. The assessment considered current impacts, historical experience, projected future changes, affected sectors, exposed infrastructure, vulnerable groups, possible cascading effects, and feedback received through stakeholder and expert engagement. The four severity categories used were: limited, moderate, substantial and critical.

Heavy rainfall / flash flooding

The current severity of heavy rainfall / flash flooding is assessed as substantial. This risk is already present in Bilhorod-Dnistrovskyi and has visible consequences for the municipality. Heavy rainfall events can overload the stormwater system, flood streets, block transport movement, damage homes, roads and public buildings, trigger erosion and landslides, and increase untreated stormwater discharge into the Dniester Estuary.

The project application identifies flooding as a recurring problem, with the August 2019 event used as a clear example: 120 mm of rain fell in only a few hours, causing widespread flooding, damage to homes, roads and public facilities, including the collapse of the Administrative Service Centre. The same source also highlights transport paralysis, traffic accidents, road damage, landslides, erosion and pollution of the Dniester Estuary as relevant consequences of heavy rainfall and insufficient drainage capacity.

The severity is assessed as substantial, rather than limited or moderate, because the impacts are not restricted to one location or one sector. Heavy rainfall affects transport, public infrastructure, residential areas, roads, sewage and stormwater systems, public safety, environmental quality and the local economy. The consequences can also be cascading. Blocked roads can delay emergency response and access to public services. Overloaded drainage can increase pollution. Repeated flood damage can increase maintenance costs and reduce the municipality's ability to invest in long-term resilience.

For the future period, the severity of heavy rainfall / flash flooding is assessed as critical. This is because the risk is already serious under current conditions, while the municipality has limited drainage capacity and limited financial and technical resources for large-scale infrastructure improvements. The heavy rainfall analysis confirms that extreme precipitation remains a relevant hazard under future climate scenarios. Even where the precise magnitude of change varies by scenario and time horizon, the combination of extreme rainfall, ageing infrastructure, insufficient stormwater management capacity and exposed urban areas means that future impacts could become more severe if adaptation measures are not implemented.

Stakeholder feedback strengthened this severity assessment. Participants in the Phase 2 meetings confirmed that heavy rainfall is perceived locally as the most visible and disruptive climate risk. Their perspective is important because it links the technical rainfall thresholds and model outputs with real local experience: flooded streets, blocked movement, damage to infrastructure and pollution of the Dniester Estuary. This confirms that the risk is not only theoretical or model-based, but already affects municipal functioning.

Decision-makers and municipal staff have practical knowledge of flood impacts and emergency responses, but further capacity-building is still needed to systematically interpret climate projections, risk maps and investment priorities. The CLIMAAX process therefore contributes to improving the understanding of risk severity and turning local experience into structured adaptation planning.

Heatwaves

The current severity of heatwaves is assessed as moderate to substantial. Heatwaves are less visibly disruptive than flash floods, but they are already relevant for Bilhorod-Dnistrovskyi because the municipality is located in southern Ukraine, has warm and dry summer conditions, and includes dense urban areas, industrial land, paved surfaces and places with limited tree cover. These conditions can increase heat stress, especially in public spaces and around social infrastructure.

The Phase 1 assessment already identified heatwaves as one of the main hazards for the municipality. It used satellite-derived land surface temperature data, WorldPop demographic data and social infrastructure information to identify heat-risk patterns. Vulnerable groups considered in the assessment included children under five and elderly people aged 65 and above. Exposed facilities included schools, kindergartens, healthcare facilities, open-air markets and key passenger transport hubs.

The Phase 2 XCLIM analysis prepared by Anatoliy Smaliychuk strengthens the severity assessment. Using locally adapted thresholds — daytime maximum temperature above 31.5°C, minimum night temperature above 15°C, and at least five consecutive days — the results show a clear increase in heatwave days. The historical reference period 1971–1990 recorded 15 heatwave days in total, while the future period 2056–2060 shows 38 heatwave days under RCP4.5 and 41 heatwave days under RCP8.5. The mean annual number of heatwave days increases from 0.75 historically to 7.6 under RCP4.5 and 8.2 under RCP8.5.

For the future period, the severity of heatwaves is assessed as substantial. The risk is not assessed as critical at this stage because the available analysis does not provide evidence of widespread direct mortality, large-scale economic loss or irreversible ecosystem destruction.

However, the projected increase in heatwave occurrence is significant, and the consequences for public health, social services, schools, kindergartens, healthcare facilities and exposed public spaces may become serious if adaptation measures are not introduced.

The potential cascading effects of heatwaves include increased demand for healthcare services, higher pressure on elderly care and social support, reduced comfort and safety in public spaces, lower productivity for outdoor workers, higher energy demand for cooling, and increased stress on vulnerable residents. If heatwaves coincide with drought conditions or electricity supply constraints, the consequences could become more severe.

Stakeholder and expert discussions enriched the severity assessment by showing that heatwaves should not be treated as a secondary risk. While flash flooding remains the most visible hazard, heatwave exposure affects people differently and may be underestimated because its impacts are less immediate. The focus on vulnerable groups changed the perception of severity: for healthy adults the current risk may seem moderate, but for elderly people, young children and people using exposed public spaces, the risk is already more serious.

Overall, the severity assessment shows that heavy rainfall / flash flooding is currently the most severe risk, while heatwaves are a growing risk whose severity will increase substantially in the future.

2.4.5 Understand Resilience Capacity

Resilience capacity was assessed according to the categories low, medium, substantial and high, considering financial, human, physical, natural and social capacity.

For heavy rainfall / flash flooding, resilience capacity is assessed as low to medium. The municipality has practical experience in responding to flood events, but the current system is mainly reactive. Existing measures include emergency response, temporary water pumping, road repairs and local maintenance after heavy rainfall. These actions reduce immediate damage but do not solve the main problem: insufficient stormwater drainage capacity.

The main weak spots are the limited stormwater infrastructure, lack of detailed drainage data, limited municipal budget, and restricted capacity to prepare and finance large infrastructure works. The Dniester Estuary is also exposed, because untreated stormwater runoff can carry pollutants into the water body. The ongoing war further limits public investment and institutional capacity.

Human and institutional capacity is assessed as moderate. The municipality has experience in public service management and project implementation, and the CLIMAAX process has improved understanding of climate risk. However, further technical support is needed for drainage planning, risk monitoring, feasibility studies and investment preparation.

For heatwaves, resilience capacity is assessed as medium. The municipality already has responsibilities relevant to heat-risk reduction, including public spaces, greenery, schools, kindergartens, healthcare facilities, social services and public communication. This gives a basic institutional foundation for action.

However, heatwave response is not yet systematic. There is no dedicated local heat-health plan, cooling-space system, or structured monitoring of vulnerable groups during heat events. Some low-cost measures can be introduced relatively quickly, such as public awareness, heat warnings, shading priorities and identification of cooling spaces. More substantial measures, such as urban greening, public space redesign and building adaptation, will require additional funding.

Overall, the municipality has basic capacity and local knowledge, but not yet sufficient technical, financial and infrastructure capacity to fully manage the two risks. Phase 3 should therefore focus on strengthening capacity through practical planning, clearer responsibilities and preparation of fundable adaptation projects.

2.4.6 Decide on Risk Priority

Risk priority was assigned by combining severity, urgency and resilience capacity.

Heavy rainfall / flash flooding is the highest priority risk. It is already causing visible impacts, including flooded streets, blocked transport, damage to infrastructure, pressure on drainage systems and pollution risks for the Dniester Estuary. Its current severity is substantial, future severity may become critical, urgency is immediate, and resilience capacity is low to medium. This means that flood and stormwater management must be the first priority in Phase 3.

Heatwaves are assessed as a high and increasing priority. They are currently less visible than flash flooding, but Phase 2 results show a clear increase in future heatwave days. The risk is particularly relevant for elderly people, young children and users of exposed public spaces, schools, kindergartens, healthcare facilities, open-air markets and transport hubs. Current resilience capacity is medium, but heat adaptation is not yet systematically integrated into local planning.

The final prioritisation is therefore:

Priority 1: Heavy rainfall / flash flooding — immediate action required.

Priority 2: Heatwaves — more systematic action required now to avoid higher future impacts.

Some measures can address both risks, especially urban greenery, nature-based solutions, improved public spaces and better maintenance of drainage corridors. These combined measures should be prioritised where possible.

2.5 Monitoring and Evaluation

Phase 2 confirmed that the hazard selection made in Phase 1 remains valid. Heavy rainfall / flash flooding and heatwaves are the two main risks for Bilhorod-Dnistrovskyi. The main added value of Phase 2 was the deeper interpretation of these risks and the additional XCLIM heatwave analysis, which showed a clear increase in future heatwave days.

The most useful learning from Phase 2 is that technical results must be interpreted together with local knowledge. Climate models and open datasets provide an important basis, but they are not enough for detailed municipal planning. Stakeholder meetings helped confirm that flash flooding is the most visible current risk, while expert analysis showed that heatwaves are becoming a stronger future risk.

The main difficulty was data availability. Detailed local data on drainage capacity, flood-prone streets, previous damage, infrastructure condition, vulnerable households and cooling access is still limited. For heavy rainfall, the available climate data is useful for strategic assessment but not sufficient for a street-level flood model. For heatwaves, more local information is needed on vulnerable people, building conditions, tree cover and cooling options.

At present, the municipality does not have a dedicated monitoring system for these two climate risks. Climate-related events are managed through existing municipal and emergency response structures, but Phase 3 should define simple indicators, such as flood-prone locations, number of affected public facilities, drainage bottlenecks, heat-exposed social infrastructure, heatwave days, and implemented adaptation measures.

What worked well was the combination of CLIMAAX workflows, expert input and stakeholder validation. What worked less well was the limited access to detailed local data. Resources were used efficiently by relying on available datasets and expert interpretation, but the next phase will need more local technical information to prepare investment-ready measures.

The CRA improved the municipality's understanding of climate risk and created a stronger basis for adaptation planning, public communication and future funding applications.

2.6 Work plan Phase 3

Phase 3 will translate the Phase 2 risk findings into practical adaptation planning. The main outputs will be the Local Climate Risk Management Plan, sectoral Adaptation Strategies, and preparation of bankable project ideas for external funding.

For heavy rainfall / flash flooding, Phase 3 will focus on stormwater and flood-risk priorities. This includes identifying flood-prone streets and transport nodes, drainage bottlenecks, exposed public buildings, areas affected by runoff, and measures to reduce polluted discharge into the Dniester Estuary. The work should lead to a clear list of priority interventions, such as drainage improvement, maintenance works, nature-based retention measures and protection of critical infrastructure.

For heatwaves, Phase 3 will focus on integrating heat-risk reduction into local planning. Priority locations should include schools, kindergartens, healthcare facilities, open-air markets, transport hubs and dense urban areas with limited shading. Measures may include urban greenery, shading, cooling spaces, public heat warnings and targeted communication for vulnerable groups.

The sectoral strategies should connect directly to the Phase 2 findings. The water strategy should address stormwater, drainage and flood mitigation. The greenery strategy should support both cooling and runoff management. The drought-related strategy should be treated only where it links to heat, vegetation stress and water management, unless additional data becomes available.

The Bankability LAB will identify which measures can be developed into fundable projects. It should prioritise stormwater management and flood mitigation, while also including heat-risk and green infrastructure measures where they are realistic and fundable.

Phase 3 will not include full engineering design, detailed construction documentation or a complete street-level flood model. These require additional surveys, technical data and funding. Instead, Phase 3 will define priorities, responsibilities, adaptation measures and funding-oriented project concepts.

The final phase should therefore move the project from risk assessment to implementation planning: flash flooding as the immediate priority, and heatwaves as a growing risk to be integrated into urban, public health and greenery planning.

3 Conclusions Phase 2- Climate risk assessment

Phase 2 confirmed the main findings of Phase 1 and added a more detailed interpretation of climate risks for Bilhorod-Dnistrovskyi. The assessment confirmed that heavy rainfall / flash flooding and heatwaves remain the two priority climate risks for the municipality. No new hazard was added in Phase 2, but the analysis was deepened, especially for heatwaves, through the additional XCLIM-based assessment prepared by Anatoliy Smaliychuk.

The main added value of Phase 2 is the locally adapted heatwave analysis. While Phase 1 relied mainly on the CLIMAAX heatwave workflow, satellite-derived land surface temperature data and exposure/vulnerability layers, Phase 2 introduced an additional method using local heatwave thresholds: daytime maximum temperature above 31.5°C, night minimum temperature above 15°C, and a minimum duration of five consecutive days. This made the assessment more relevant to the local climate conditions of Bilhorod-Dnistrovskyi.

The XCLIM results show a clear increase in future heatwave risk. In the historical reference period 1971–1990, the analysis identified 15 heatwave days in total, equal to an average of 0.75 heatwave days per year. For the future period 2056–2060, the projected number of heatwave days increases to 38 days under RCP4.5 and 41 days under RCP8.5. The mean annual number of heatwave days increases to 7.6 under RCP4.5 and 8.2 under RCP8.5. This confirms that heatwaves should be treated as a growing risk for public health, social infrastructure and urban planning.

For heavy rainfall / flash flooding, Phase 2 confirmed the relevance of the Phase 1 findings. The assessment continued to use the locally relevant thresholds of 100 mm in 24 hours for heavy rain and 90 mm in 3 hours for heavy showers. The results indicate that intense precipitation remains a serious risk for the municipality, especially because of limited stormwater drainage capacity, exposed roads and public infrastructure, and the risk of untreated runoff entering the Dniester Estuary.

The risk prioritisation shows that heavy rainfall / flash flooding is the highest priority risk. It is already causing visible disruption and damage, and its urgency is assessed as immediate action needed. The risk affects roads, transport movement, drainage systems, public buildings, residential areas, erosion-prone locations and the Dniester Estuary. The municipality's resilience capacity is assessed as low to medium, mainly because current measures remain mostly reactive and financial and technical resources are limited.

Heatwaves are assessed as a high and increasing priority risk. The current risk is less visible than flash flooding, but future projections show that it will become more important. The risk is particularly relevant for elderly people, young children, schools, kindergartens, healthcare facilities, open-air markets, transport hubs and dense urban areas with limited shading. The municipality has a basic institutional foundation to address heatwaves, but heat-risk reduction is not yet systematically integrated into local planning.

Stakeholder engagement during Phase 2 helped validate the technical findings. The local meetings held on 15 January 2026 and 6 May 2026 confirmed that heavy rainfall and flash flooding are perceived as the most immediate and disruptive risks. The discussions also helped strengthen attention to heatwaves, especially in relation to vulnerable groups and exposed public spaces. The engagement process showed that the climate risk assessment is most useful when technical outputs are interpreted together with local knowledge.

Several challenges were addressed in Phase 2. The project clarified the priority risks, improved the interpretation of results, added locally adapted heatwave analysis, compared Phase 2 findings with Phase 1, and identified clear priorities for Phase 3. The assessment also helped translate climate data into practical planning messages for the municipality.

However, several challenges remain. The most important limitation is the lack of detailed local data. Detailed meteorological data, drainage-system information, flood-prone street data, infrastructure condition data, records of past flood damage, and spatially specific data on vulnerable groups are still limited. For this reason, the heavy rainfall assessment could not produce a detailed street-level flood model. Similarly, the heatwave assessment would benefit from better local data on building conditions, tree cover, cooling access and vulnerable households.

Phase 2 therefore provides a stronger strategic risk assessment, but not a full technical design for adaptation measures. It does not include full engineering design of the stormwater system, detailed construction documentation, or a complete local heat-health response plan. These should be developed later through dedicated technical studies, feasibility assessments and funding applications.

The main conclusion is that Bilhorod-Dnistrovskyi should move from reactive response to structured adaptation planning. In Phase 3, the municipality should prioritise stormwater management and flash flood resilience, while also integrating heat-risk reduction into urban planning, public health, greenery and social infrastructure measures. The results of Phase 2 provide the basis for the Local Climate Risk Management Plan, sectoral Adaptation Strategies and the preparation of bankable adaptation projects.

4 Progress evaluation

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
vailable Topical Data Atlas developed	Completed in Phase 1 and used as a basis for Phase 2.
CLIMAAX common methodology dataset drafted, including relevant gaps in climate risk data identified and assessed	Completed in Phase 1 and further refined in Phase 2 through updated interpretation and additional heatwave analysis.
Local high-resolution analysis map and multi-risk assessments drawn upon and prepared	Achieved in Phase 2. Heatwave risk was refined through Landsat-based heat exposure analysis and additional XCLIM heatwave assessment. Heavy rainfall / flash flooding was assessed using rainfall thresholds and projection outputs.
Open Data LAB made available online and pre-consulted	Partly achieved / in progress. Datasets and outputs have been prepared for sharing, but final upload, metadata completion and verification should be confirmed before final submission.

Table 4-2 Overview milestones

Milestones	*Progress*
M4: Climate-related historical data and detailed maps obtained	Achieved. Phase 2 used available historical and projected climate data, local knowledge, heatwave maps, exposure/vulnerability layers and additional XCLIM-based heatwave analysis.
M5: Climate-related data made publicly available	In progress. The relevant outputs have been identified for sharing through the Open Data LAB / CLIMAAX repository process. Final upload and metadata checks should be completed or verified before final submission.
M6: Local Climate Risk Management Plans and Adaptation Strategies	Initiated but not completed. Phase 2 defines the risk priorities and evidence base; the actual plans and strategies will be developed in Phase 3.