Deliverable Phase 1 – Climate risk assessment

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

Ukraine, Bilhorod Dnistrovskyi

Version 2.0 | May 2025

HORIZON-MISS-2021-CLIMA-02-01 - Development of climate change risk assessments in European regions and communities based on a transparent and harmonised Climate Risk Assessment approach

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101093864. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

Document Information

Deliverable Title	Phase 1 – Climate risk assessment
Brief Description	Climate risk assessment for Bilhorod Dnistrovskyi focused of HEATWAVES and HEAVY RAINFALL workflows
Project name	Evidence-driven climate risk adaptation measures for Bilhorod Dnistrovskyi
Country	Ukraine
Region/Municipality	Bilhorod Dnistrovskyi
Leading Institution	Bilhorod Dnistrovskyi
Author(s)	• Marcin Jarzynowski (Development Policy Foundation) • Olga Polinger (Municipality of Bilhorod Dnistrovskyi)
Deliverable submission date	30/09/2025
Final version delivery date	30/09/2025
Nature of the Deliverable	R – Report
Dissemination Level	PU - Public

Version	Date	Change editors	Changes
1.0	…	Institution name	Deliverable submitted
2.0	…	CLIMAAX's FSTP team	Review completed
5.0	…		Final version to be submitted

Table of contents

List of figures

List of tables

Abbreviations and acronyms

Insert here all acronyms appearing along the deliverable in alphabetical order. This text marked in green should be deleted before submitting the deliverable.

Abbreviation / acronym	Description
M&E	Monitoring and Evaluation
NBS	Nature-Based Solutions
ND-GAIN	Notre Dame Global Adaptation Initiative Index
O&M	Operation and Maintenance
OSM	OpenStreetMap
RDH	Risk Data Hub (EU)
SECAP	Sustainable Energy and Climate Action Plan
SESU	State Emergency Service of Ukraine

Executive summary

This deliverable presents the Phase 1 Climate Risk Assessment (CRA) for Bilhorod-Dnistrovskyi, conducted under the EDCRAMBD project and aligned with the CLIMAAX framework. The CRA addresses acute and recurrent climate risks driven by intense rainfall, which cause flash flooding, transport disruption, infrastructure damage, landslides/erosion, and pollution pulses to the Dniester Estuary. The assessment sets a standardized baseline, defines scope and workflows, compiles relevant datasets, and prepares the methodological foundation for high-resolution analyses and planning in Phases 2–3.

The assessment confirms that pluvial (stormwater) flash flooding is the primary hazard, with cascading impacts on public services, mobility, and environmental quality. Historic evidence, including the August 2019 storm (120 mm in a few hours), underscores the high severity and urgency. Additional risks include rainfall-induced landslides/erosion and potential compound effects from estuarine backwater at stormwater outfalls. Vulnerability is elevated due to aging drainage infrastructure, budget constraints, limited technical capacity, and wartime disruptions.

Phase 1 actions included:

- Scoping and stakeholder mapping with defined roles and risk ownership.
- Screening of main hazards and selection of two workflows for Phase 2: Urban pluvial flash flood risk to people, buildings, and critical infrastructure.
- Identification of scenario assumptions for near-, mid-, and long-term horizons consistent with SSP-based climate projections and plausible socio-economic pathways.
- Baseline data inventory using CLIMAAX-recommended sources (Copernicus DEM GLO-30, WorldCover 10 m, OSM, ERA5/E-OBS) and preparation of data requests to Ukrainian national institutes (UHMI, Boris Sreznevsky Observatory) for local IDF curves, sub-hourly rainfall, and historical event records.
- Definition of preliminary risk indicators and M&E approach.
- Work plan for high-resolution modelling, Open Data Lab, and Bankability Lab.

1 Introduction

1.1 Background

Bilhorod-Dnistrovskyi is a historic city in Odesa Oblast, located in southern Ukraine on the right bank of the Dniester Estuary, approximately 20 kilometers from the Black Sea. With a population of around 47,700 residents, the city combines rich cultural heritage with strategic economic importance as a regional transport and logistics hub, home to a major sea port and railway connections. Known historically as Akkerman, the city features well-preserved medieval fortifications and a diverse architectural legacy, reflecting centuries of multicultural influence. Its economy is based on industries such as construction materials, furniture, clothing, and port-related services, making it a vital center for trade and employment in the region.

The community of Bilhorod-Dnistrovskyi is deeply connected to its natural environment, particularly the ecologically significant Dniester Estuary, which supports local fisheries, agriculture, and tourism. However, the city faces growing challenges due to climate change, especially frequent and intense flash floods caused by heavy rainfall. Inadequate stormwater drainage systems have led to recurring flooding that damages homes, disrupts transportation, and threatens public infrastructure—highlighting the urgent need for climate adaptation. These environmental stresses are compounded by limited municipal resources and the broader impacts of the ongoing war, which have strained public services and delayed critical infrastructure investments.

Despite these challenges, Bilhorod-Dnistrovskyi has demonstrated strong civic initiative and forward-thinking governance. It was among the first Ukrainian cities to develop a Sustainable Energy and Climate Action Plan (SECAP), supported by USAID in 2017, showcasing its commitment to sustainability and resilience. The local administration actively engages with international partners and prioritizes transparency, community well-being, and environmental protection.

1.2 Main objectives of the project

The primary objective of the EDCRAMBD project is to strengthen the climate resilience of Bilhorod-Dnistrovskyi—a historically and economically significant city in southern Ukraine—by establishing a robust, evidence-based foundation for climate risk assessment and adaptation planning. The project is structured around the three-phase CLIMAAX methodology, aiming to generate high-quality, standardized climate risk data, develop localized adaptation strategies, and enhance the city's capacity to secure external funding for long-term resilience-building initiatives.

Bilhorod-Dnistrovskyi faces acute vulnerability to climate change impacts, particularly recurrent flash floods triggered by extreme rainfall events, such as the devastating 120 mm downpour in August 2019 that overwhelmed the city's outdated stormwater infrastructure. This event caused severe damage to public buildings, roads, and utilities, disrupted critical transport links including the railway crossing, and led to environmental degradation through untreated runoff polluting the ecologically sensitive Dniester Estuary. With limited financial and technical resources—and further constrained by the ongoing war—Bilhorod-Dnistrovskyi currently lacks the tools and data necessary to transition from reactive crisis management to proactive, sustainable climate adaptation.

The significance of this project lies in its potential to transform how the city understands and responds to climate risks. By implementing the CLIMAAX Handbook methodology, the project will produce a harmonized climate risk dataset compatible with European frameworks, enabling cross-regional comparisons and integration into EU policy processes. This is particularly strategic given Ukraine's status as an EU candidate country and the alignment required with the European Green Deal and EU Adaptation Strategy. Phase 1 will map existing data and adapt it to the CLIMAAX common framework, identifying critical gaps. Phase 2 will deliver high-resolution, localized risk assessments focusing on flooding, landslides, and environmental pollution, culminating in the establishment of an Open Data LAB to promote transparency and stakeholder engagement. In Phase 3, these findings will inform the development of a Local Climate Risk Management Plan and Adaptation Strategy, co-created with local authorities, experts, and communities.

A key expected benefit of applying the CLIMAAX Handbook is the enhancement of bankability—the ability to design and propose climate adaptation projects that meet the eligibility criteria of international donors, EU funding mechanisms, and future post-war reconstruction programs. Through the Bankability LAB, the project will prepare feasibility studies, environmental impact assessments, and funding applications for priority interventions such as green-blue infrastructure, drainage system upgrades, and ecosystem restoration in the estuary zone. The involvement of EU and Ukrainian experts ensures both technical rigor and alignment with best practices.

Ultimately, the project will empower Bilhorod-Dnistrovskyi to build long-term resilience, protect its population and economy, preserve its natural assets, and serve as a model for other Ukrainian municipalities facing similar challenges. It represents a crucial step toward sustainable urban development in a climate-vulnerable region, grounded in science, inclusivity, and European integration.

1.3 Project team

Olga Tsipulenko — Director, Department of Economics and Infrastructure Development, Bilhorod-Dnistrovskyi City Council (Project Lead; Decision-making liaison)

Olga Polinger — Head, Tourism and International Relations Division, Department of Economy and Infrastructure Development, Bilhorod-Dnistrovskyi City Council (Coordination; Stakeholder engagement)

Wojciech Szpociński — Development Policy Foundation (Methodology; Policy-finance alignment)

Sylwia Szparkowska — Development Policy Foundation (Project management support; Finance and bankability)

Marcin Jarzynowski — External Expert (Funding for SMEs/NGOs; fundraising for urban resilience)

Anatoliy Smaliychuk - Data Analyst

1.4 Outline of the document's structure

Executive summary: Key messages, Phase 1 results, conclusions, and next steps.

1 Introduction: Background, objectives, team, and document structure.

2 Climate risk assessment – Phase 1:

2.1 Scoping: Objectives, context, participation, and risk ownership.

2.2 Risk Exploration: Hazard screening, workflow selection, and scenario framing.

2.3 Risk Analysis: Application plan of selected workflows and Phase 1 data overview.

2.4 Preliminary Findings: Severity, urgency, capacity.

2.5 Preliminary M&E: Learning, feedback, and data needs.

2.6 Work Plan: Activities for Phases 2–3 and out-of-scope items.

3 Conclusions Phase 1: Main conclusions and key findings.

4 Progress evaluation: KPIs and milestones.

5 Supporting documentation: Outputs and Zenodo deposit overview.

2 Climate risk assessment – phase 1

2.1 Scoping

In this phase clear objectives aligned with the CLIMAAX three-phase methodology have been defined: to build a standardized baseline risk profile (Phase 1), conduct high-resolution flood and heat risk modeling (Phase 2), and co-develop a bankable Local Climate Risk Management Plan (Phase 3). The context reflects a city grappling with aging infrastructure, recurrent flash floods, intensifying heat stress, and wartime constraints — yet demonstrating strong governance commitment through its 2017 SECAP and active stakeholder engagement. Crucially, this phase mapped institutional roles and risk ownership across municipal departments, utilities, emergency services, environmental agencies, academia, civil society, and vulnerable communities — ensuring that risk analysis is not only technically robust but socially grounded and institutionally owned. This structured, inclusive scoping ensures Phase 2 activities are focused, feasible, and directly responsive to local priorities.

2.1.1 Objectives

Objective, purpose and expected outcomes of the CRA (aligned with CLIMAAX phases)

Build a standardised, comparable baseline risk profile (Phase 1)

Aggregate and quality-check all relevant international and national datasets using the CLIMAAX Toolbox.

Produce a CLIMAAX-compliant dataset for Bilhorod-Dnistrovskyi; identify key data gaps.

Deliverables: data inventory and quality report; initial hazard–exposure–vulnerability screens; map of 2019 flood event impacts for calibration/validation.

Conduct local, high-resolution multi-risk assessment focused on pluvial flash floods and landslide/erosion hotspots (Phase 2)

Develop high-resolution rainfall and hydrologic/hydraulic analyses to map flood depths, extents, velocities, and duration for design storms and return periods.

Quantify direct and indirect risks to people, critical infrastructure, public services, economy, and environment (including Dniester estuary pollution loads).

Deliverables: high-resolution risk maps; sectoral impact analysis; social vulnerability analysis; uncertainty ranges.

Create an open, shared evidence base and enable local capacity (Phase 2)

Launch an Open Data Lab making non-sensitive inputs, methods, and outputs FAIR and reusable; provide trainings to municipal staff and local partners.

Deliverables: data portal, metadata, versioned scripts/workflows where feasible, training materials.

Develop actionable Local Climate Risk Management Plan and Adaptation Strategy (Phase 3)

Co-design a prioritized, costed portfolio of adaptation measures (gray, green–blue, hybrid, policy/regulatory).

Define phasing, responsibilities, financing pathways, and an M&E framework with indicators and triggers.

Deliverables: L-CRMP & Adaptation Strategy; implementation roadmap; monitoring plan.

Turn strategy into investment (Phase 3)

Bankability Lab to turn priority measures into fundable projects, with pre-feasibility, E&S screening, and identification of EU/international/post-war reconstruction finance.

Deliverables: project fiches, concept notes, pre-feasibility/ESIA scoping as required, funding pipeline and timeline.

How the objectives feed into policy and decision-making

Urban planning and permitting: integrate flood hazard overlays into the General Plan/land-use zoning; set SUDS/green infrastructure requirements for new developments; update building codes and road standards to account for design storms.

Infrastructure planning: stormwater master plan with prioritized pipe upgrades, detention/retention, green–blue corridors, pumping stations, emergency bypasses; resilient design standards for road and rail assets and critical facilities.

Environmental management: measures to reduce pollutant loads to the Dniester estuary; nature-based solutions restoring riparian buffers and retention areas; contributions to basin-wide objectives.

SECAP and sectoral plans: update and complement the 2017 SECAP with adaptation chapters, indicators and financing plan; align with regional emergency preparedness plans.

Budgeting and finance: inform multi-annual investment plans; underpin applications to EU instruments and reconstruction funds with evidence of risk reduction and cost-effectiveness.

Governance and participation: formalize a cross-departmental climate risk management process; maintain the Open Data Lab for transparency and continuous updates.

2.1.2 Context

Existing assessment and handling of hazards

- Historical evidence: August 2019 extreme rainfall (≈120 mm in a few hours) triggered widespread pluvial flooding, transport paralysis, infrastructure damage (including ASC collapse), and likely elevated pollutant loads to the estuary.
- Current practice: Reactive measures (pumping, road repairs) predominate; limited strategic stormwater master planning and limited monitoring of stormwater quality.
- Data and institutions: National hydromet and geophysical institutes (UHMI; Boris Sreznevsky Observatory) hold meteorological records and likely IDF curves; local data on drainage assets requires consolidation.

Problem framing and wider system

- Systemic issue: Insufficient stormwater conveyance and storage capacity relative to short-duration, high-intensity rainfall; high impervious cover; local topographic depressions; outfall performance potentially constrained during estuarine high water.

- Regional/national relevance: Aligns with EU Adaptation Strategy and European Green Deal; supports Ukraine's EU accession path and post-war recovery priorities for resilient infrastructure and environmental health.

Governance context

- Local: Bilhorod-Dnistrovskyi City Council manages urban planning, utilities, mobility, and public assets; 2017 SECAP provides a platform to integrate adaptation.
- Regional/National: Odesa Oblast Administration coordination; SESU responsibilities for emergency preparedness/response; environmental oversight by basin/estuary authorities; national standards for construction, roads, and water management apply.
- Finance: Municipal budget constraints; external funding needed (EU instruments, international donors, post-war reconstruction).

Relevant sectors and potential impacts

- People and social services: Flooding of residential areas; access disruptions to health/education; disproportionate impacts on vulnerable groups.
- Transport/logistics: Road and rail disruption; port and yard operations affected; supply chain delays.
- Utilities: Stormwater/wastewater surcharging; power and telecom node exposure; water quality concerns.
- Economy: Industry (construction materials, furniture, clothing), SMEs, and tourism at risk from business interruption and asset damage.
- Environment: Dniester Estuary pollution pulses; erosion and sedimentation; habitat impacts.

External initiatives and influences

- EU and international initiatives on climate resilience and green infrastructure; Copernicus/C3S datasets; CLIMAAX Toolbox; potential synergies with basin-level management (Dniester).
- Post-war reconstruction strategies emphasising resilient, green rebuilding.

Possible adaptation interventions

- Structural/grey: Priority pipe upsizing, new inlets and culverts, detention/retention basins, pump stations, backflow prevention at outfalls, road/rail drainage retrofits.
- Green–blue/NBS: Bioswales, rain gardens, permeable pavements, green streets, riparian buffers, wetland restoration, urban tree planting.
- Policy/operations: Development control (SUDS requirements), maintenance programs (gully cleaning), emergency diversion routing, early warning and response protocols.
- Water quality: First-flush capture and treatment at hotspots, sediment traps, oil/grit separators at transport nodes.

Information gaps:

Comprehensive asset inventory for stormwater/wastewater and critical facilities; estuary outfall elevations and backwater observations; recent landslide/erosion incident records.

2.1.3 Participation and risk ownership

Stakeholder setup and mapping

- Lead and coordination:
    - Bilhorod-Dnistrovskyi City Council (Project owner; coordination; planning; finance)
    - Department of Economy and Infrastructure Development (technical coordination and sectoral liaison)
- Municipal operators:
    - Water/wastewater/stormwater utility (Vodokanal or equivalent) — operations, asset data, maintenance
    - Roads/transport department; coordination with Ukravtodor and rail operator (Ukrzaliznytsia)
    - Power and telecom operators (asset exposure and continuity planning)
- Regional/national:
    - Odesa Oblast Administration; SESU (emergency planning/response)
    - UHMI and Boris Sreznevsky Observatory (climate and hydromet data)
    - Cadastre/geodesy authority (topographic and parcel data)
- Environment/estuary:
    - Dniester basin/estuary management authorities; environmental inspectorates
- Academia/research:
    - National University of Odesa and EU research partners (methods and peer review)
- Civil society and NGOs:
    - MAMA-86-Odesa; Social Ecological Association “Chaika”; International Social-Ecologic Union (public participation, citizen science)
- Private sector:
    - Port and railway operators; logistics companies; industry associations; SMEs
- Vulnerable groups:
    - Representatives of elderly, low-income households, people with disabilities, displaced persons; resident committees in known hotspots
- External experts:
    - Development Policy Foundation; Syntegra ESG; GIS/IT experts

Engagement approach (Phase 1–3)

- Phase 1: Stakeholder mapping, initial workshop, data-sharing agreements; targeted interviews with utilities, transport, and estuary authorities; community collection of 2019 flood evidence (photos, locations).

- Phase 2: Co-design sessions for hotspot validation; Open Data Lab launch with training; public-facing dashboards; participatory prioritization of measures.
- Phase 3: Investment roundtables (Bankability Lab); public consultation on L-CRMP & Adaptation Strategy.

Risk ownership

- Hazard monitoring and warning: UHMI (meteorological), SESU and municipality (alerts and response).
- Drainage infrastructure performance: Water/stormwater utility and municipal roads/engineering departments.
- Critical facility continuity: Facility owners/operators with municipal oversight.
- Environmental quality: Estuary/basin authorities and environmental inspectorates; municipal environmental unit for local measures.
- Planning and regulation: City Council (General Plan, permitting, development control).
- Financing and implementation: City Council leads, with co-financing by regional/national programs and external donors.

Acceptable risk levels (to be validated)

- Design performance for priority networks and critical assets at 1-in-10 to 1-in-20 year storms (near term), moving toward 1-in-50 year over time where economically justified; maximum tolerable depth on strategic roads ≤0.15–0.20 m; no flooding in key critical facilities for 1-in-20 year events.
- Residual risk managed via emergency plans, redundancies, and insurance where available.

Communication of results

- Channels: Municipal website (bilgorodd.gov.ua), Open Data Lab portal, stakeholder briefings, public meetings, social media, and SESU alert channels.
- Products: Non-sensitive maps, dashboards, technical notes, plain-language summaries, FAQs, and policy briefs for decision-makers.

2.2 Risk Exploration

2.2.1 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).

2.2.2 Workflow selection

Based on the identified main hazards, two primary workflows are selected for detailed analysis in Phase 2:

2.2.2.1 **Workflow #1:** Urban Pluvial Flash Flood Risk

- Hazard: Intense rainfall leading to stormwater flooding.
- Exposure: Residential areas, critical infrastructure, transport networks.

- Vulnerability: High due to frequent occurrence, infrastructure damage, and impact on daily life.

2.2.2.2 **Workflow #2:** Rainfall-induced Landslide/Erosion and Stormwater Pollution Risk

- Hazard: Landslides/erosion and pollution from stormwater runoff.
- Exposure: Slopes, infrastructure (roads, buildings), Dniester Estuary ecosystem.
- Vulnerability: High due to recurrent damage, ecological importance, and potential cascading effects.

2.2.3 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

2.3.1 Workflow #1 HEATWAVES

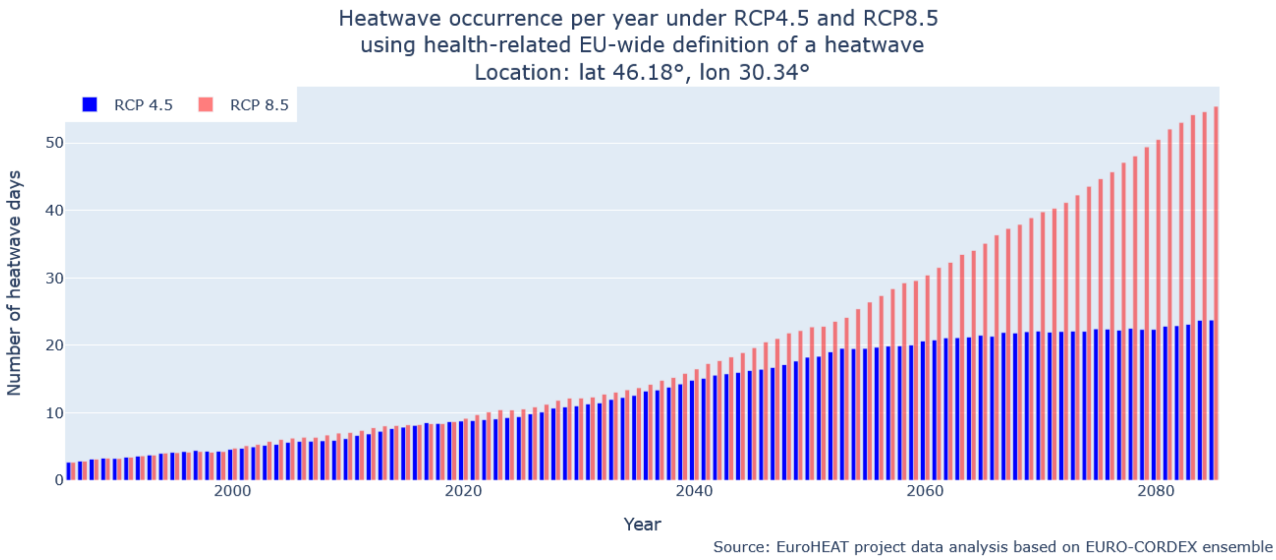
Table 2-1 Data overview workflow #1

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
Risk assessment for heatwaves based on satellite-derived data Data set: Land surface temperature data from Landsat 8 for	Data from WordPop Hub on gender and age groups disstribution for Ukraine with 100 m spatial resolution as	Data from OpenStreetMap and Master Plan of Bilhorod-Dnistrovskyi city on social infrastructure available as building footprint for schools, kindergartens, colleges, health	Heat risk level data as a raster image for target area (see image below)

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
summer period (June-August) for 2023-2025 reclassified into five categories	of 2020. Both male and female data sets were used for two wide age grops: 0-4 and ≥65 y.o.	care facilities, open air markets and key passenger transport hubs	

2.3.1.1 Hazard assessment

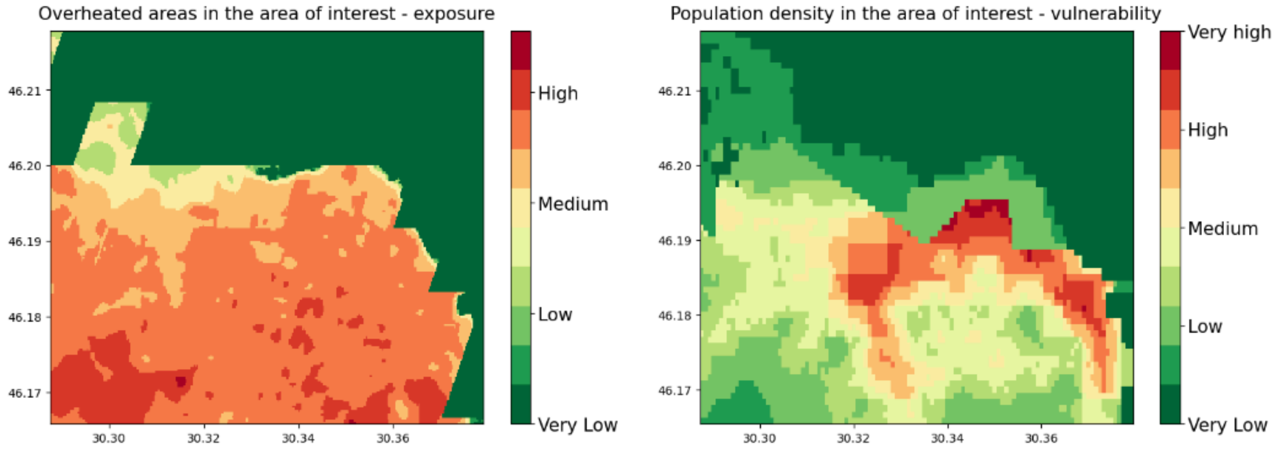
EuroHEAT methodology

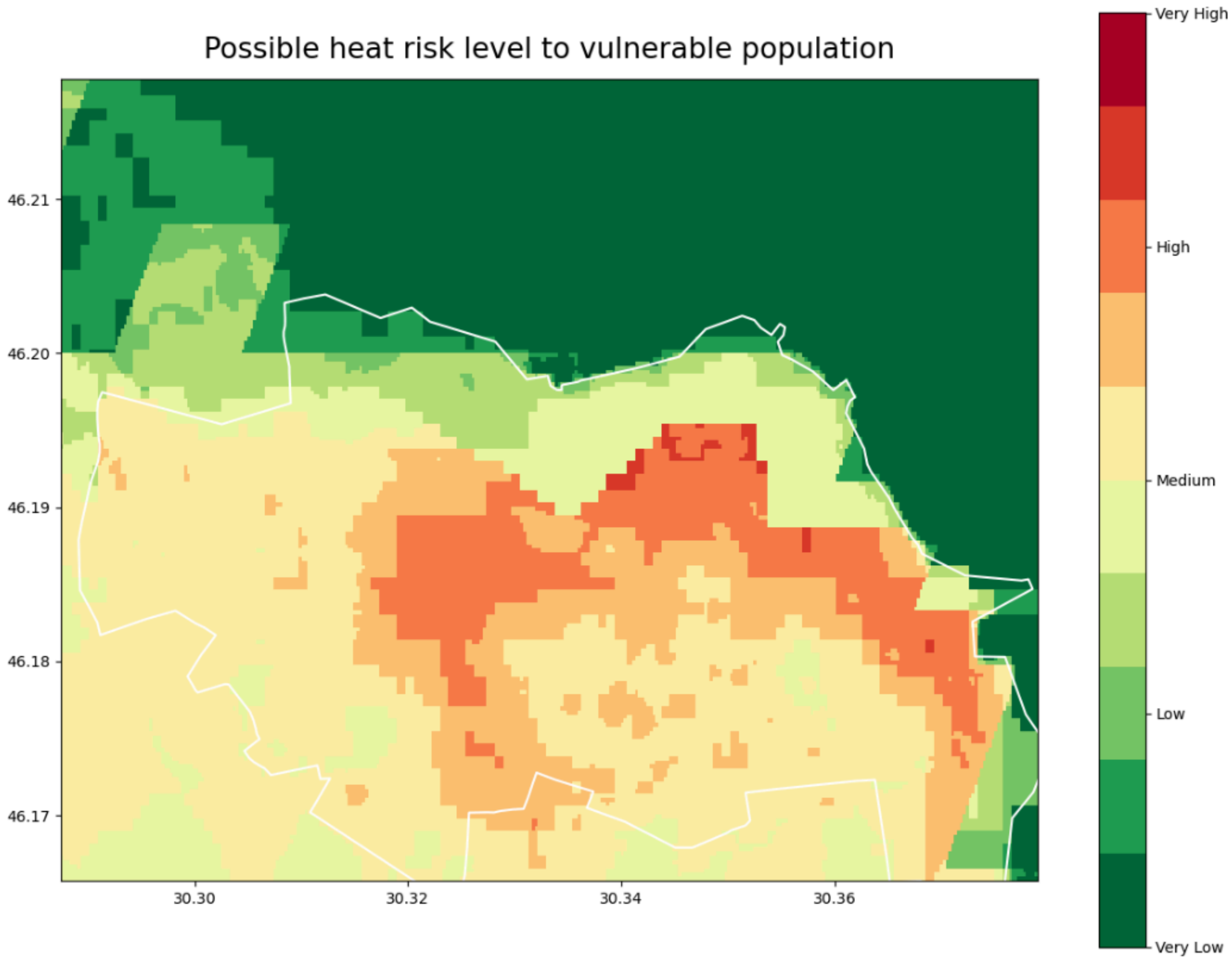


Observed and projected heatwave occurrence based on EURO-CORDEX ensemble

Year	RCP4.5	RCP8.5
2020	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

2.3.1.2 Risk assessment





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

2.3.2 Workflow #2 HEAVY RAINS

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

Table 2-2 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 under two climate change scenarios RCP 4.5 and RCP 8.5 for three future time frames: 2011-2040, 2041-2070, 2071-2100			Information about projected change to the frequency and magnitude provided in the tables below

1.1.1.1 Hazard assessment

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.

1.1.1.2 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.

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 Preliminary Key Risk Assessment Findings

2.4.1 Severity

The climate risks identified for Bilhorod-Dnistrovskyi — particularly pluvial flash flooding and heatwaves — demonstrate high severity due to their direct, cascading, and systemic impacts on human safety, infrastructure, economy, and environment.

Pluvial Flash Flooding: The August 2019 event (120 mm in a few hours) caused widespread inundation, paralyzed transport (including critical rail links), damaged municipal buildings and private homes, and likely triggered pollutant pulses into the Dniester Estuary — a Natura 2000 candidate site. Projected increases in rainfall intensity under RCP4.5 and RCP8.5 indicate that events of this magnitude may become 2–3 times more frequent by 2070–2100. Infrastructure vulnerability is exacerbated by aging drainage systems, high impervious surfaces, and topographic depressions.

Heatwaves: Satellite-derived LST analysis and EURO-CORDEX projections reveal increasing frequency and duration of heatwaves. By 2070, under RCP8.5, the city may experience over 40 heatwave days annually — up from ~5 in 2020. Vulnerable populations (elderly, children, low-income households) concentrated in dense urban zones with minimal green cover face elevated health risks, including heat stress and mortality. Critical social infrastructure (schools, clinics, markets) lacks passive cooling or emergency response protocols for extreme heat.

Cascading Risks: Flooding disrupts power/telecom nodes, triggers landslides on slopes near residential areas, and compromises wastewater treatment — leading to environmental degradation and public health threats. Heatwaves reduce labor productivity in key industrial sectors and strain water resources during drought periods.

2.4.2 Urgency

The urgency of intervention is critical, especially for pluvial flooding, which is characterized by sudden-onset, high-magnitude events with short warning windows.

Flash Floods: Historical recurrence (e.g., 2019) and projected intensification demand immediate action (0–3 years). Drainage upgrades, emergency bypasses, and early warning systems must be prioritized to prevent loss of life and critical asset failure. Delaying adaptation increases exposure exponentially as impervious cover expands.

Heatwaves: While slower in onset, heat risk is accelerating rapidly. By 2040, heatwave days could double — requiring medium-term interventions (3–7 years) such as urban greening, retrofitting of public buildings, and community cooling centers. However, given vulnerable demographics and lack of current preparedness, proactive measures should begin immediately.

Compound Risks: Estuarine backwater effects during storms + heat-induced evaporation may create novel hydro-climatic stressors. Monitoring and modeling these interactions is urgent to avoid maladaptation.

2.4.3 Capacity

Current institutional, financial, and technical capacity to manage these risks is low to moderate, severely constrained by wartime conditions, budget limitations, and fragmented governance.

- Physical Capacity: Stormwater infrastructure is outdated and undersized. No real-time monitoring or hydraulic modeling capability exists locally. Emergency response relies on ad-hoc pumping and manual clearing.

- Human & Institutional Capacity: Limited in-house expertise in climate risk modeling. Staff turnover and war-related disruptions hinder continuity. However, strong political will exists, evidenced by the 2017 SECAP and active engagement in this project.

- Financial Capacity: Municipal budgets cannot cover major infrastructure retrofits. External funding (EU, donors, post-war reconstruction) is essential but requires bankable project pipelines — currently under development via the Bankability Lab.

- Social & Natural Capacity: Civil society organizations (e.g., MAMA-86, Chaika) are active in environmental monitoring and advocacy. Urban tree canopy is sparse (<10% coverage), reducing natural cooling and stormwater retention potential.

- Policy & Planning: The 2017 SECAP provides a foundation but lacks detailed adaptation chapters, hazard mapping, or financing mechanisms. Land-use planning does not yet integrate flood overlays or SUDS requirements.

2.5 Preliminary Monitoring and Evaluation

Key Learnings from Phase 1

Data Gaps Are Critical: Lack of localised IDF curves, sub-hourly rainfall records, and asset inventories (stormwater network, building footprints with construction year) limits precision. Reliance on Copernicus/E-OBS datasets introduces uncertainty at the municipal scale.

Stakeholder Mapping Revealed Silos: Utilities, transport, and environmental agencies operate independently. Cross-sectoral coordination mechanisms must be institutionalised.

Community Knowledge Is Vital: Citizen-collected photos and testimonies from the 2019 flood provided ground truthing that was impossible via remote sensing alone. Participatory mapping will be expanded in Phase 2.

War Context Demands Flexibility: Data collection was delayed due to security constraints. Future phases must include contingency plans and remote collaboration tools.

2.6 Work plan

Phase 2 (2025–2026): High-Resolution Risk Modeling & Open Data Lab

Hydrologic-Hydraulic Modeling (Workflow #1)

- Calibrate 1D/2D flood models using 2019 event + DEM GLO-30, land cover, drainage network.
- Simulate design storms (1-in-10 to 1-in-100 yr) under RCP4.5/RCP8.5.
- Output: Flood depth/velocity maps, sectoral impact scores (buildings, roads, utilities).

Landslide/Pollution Risk Mapping (Workflow #2)

- Slope stability analysis using geological maps + rainfall thresholds.
- Pollutant load estimation for estuary using runoff coefficients + land use.
- Output: Erosion susceptibility zones, pollution hotspots.

Social Vulnerability Index

- Combine demographic (WorldPop), economic (tax records), and access (OSM) data.
- Overlay with hazard maps to identify priority intervention zones.

Open Data Lab Launch

- Deploy FAIR-compliant portal with metadata, scripts, and visualization tools.
- Train municipal staff and NGO partners in data use and update protocols.

Co-Design Workshops

- Validate risk maps with stakeholders; prioritize adaptation measures (grey/green/NBS).

Phase 3 (2026–2027): Strategy & Bankability

Local Climate Risk Management Plan (L-CRMP)

- Costed portfolio of 15–20 measures (e.g., bioswales, pump upgrades, cooling corridors).
- Phasing, responsibilities, M&E framework with KPIs (e.g., % area with reduced flood depth).

Bankability Lab

- Develop 5 pre-feasibility studies for priority projects.
- Align with EU funding criteria (LIFE, CEF, Recovery and Resilience Facility).

Out-of-Scope Items

- Sea-Level Rise: Not modeled due to distance from coast (20 km) and low projected impact by 2100.
- Agricultural Drought: Excluded as focus is urban resilience; rural impacts addressed via regional plans.
- Full Economic Loss Modeling: Deferred to Phase 3 due to data complexity and resource constraints.

3 Conclusions Phase 1- Climate risk assessment

Phase 1 successfully established a standardized, CLIMAAX-compliant baseline for climate risk assessment in Bilhorod-Dnistrovskyi, despite significant data and contextual challenges posed by the ongoing war. Key achievements include:

- *Comprehensive Scoping: Clear definition of objectives, workflows, scenarios, and stakeholder roles.*
- *Hazard Prioritisation: Pluvial flash floods and heatwaves validated as primary risks via historical evidence and future projections.*
- *Data Inventory & Gaps Identified: Aggregated global/national datasets;*
- *Risk Ownership Framework: Institutional responsibilities mapped across municipal, regional, and national actors.*
- *Methodological Foundation: Workflows selected and adapted for high-resolution modelling in Phase 2.*

Key Findings

1. *Flash Flooding Is the Most Acute Threat*

Driven by intense rainfall overwhelming inadequate drainage, with cascading impacts on mobility, infrastructure, and estuary health. Projected frequency increase demands immediate structural and nature-based interventions.

2. *Heat Risk Is Accelerating and Underestimated*
   Urban heat island effects compound demographic vulnerability. Passive cooling and green infrastructure must be integrated into urban renewal.

3. *Capacity Gaps Require Targeted Investment*
   Technical skills, real-time monitoring, and cross-departmental coordination are critical bottlenecks. The Open Data Lab and training programs will directly address these.

4. *War Context Demands Adaptive Management*
   Flexible timelines, remote collaboration, and modular project design are essential for continuity.

5. *EU Alignment Offers Strategic Leverage*
   Standardized outputs position Bilhorod-Dnistrovskyi to access EU funding and serve as a model for other Ukrainian municipalities.

Unresolved Challenges

- *Securing timely access to local meteorological and infrastructure data.*
- *Quantifying indirect economic losses and ecosystem service degradation.*
- *Ensuring sustained stakeholder engagement amid ongoing conflict.*

4 Progress evaluation and contribution to future phases

The initial climate risk assessment for Bilhorod Dnistrovskyi is the first comprehensive document providing baseline data for climate-related challenges. In the second phase it will be refined and the key findings will be published and used as the basis to apply for funding for investment under bankability LAB.

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
Completion of Phase 1 Deliverable (Report)	Achieved (This document)
Adherence to the CLIMAAX Handbook methodology for Phase 1	Achieved (Framework applied for scoping, risk exploration, preliminary analysis)
Identification and prioritisation of main climate hazards for Bilhorod-Dnistrovskyi	Achieved (Pluvial flooding, heatwaves, landslides/erosion confirmed)
Selection of core climate risk workflows for detailed analysis (Phase 2)	Achieved (Urban Pluvial Flash Flood Risk; Rainfall-induced Landslide/Erosion and Stormwater Pollution Risk workflows selected)
Completion of initial baseline data inventory using CLIMAAX-recommended sources	Achieved (Copernicus DEM, WorldCover, OSM, ERA5/E-OBS inventoried)
Identification of key local data gaps and initiation of data requests	Achieved (Specific data gaps identified)
Preliminary stakeholder mapping and engagement conducted	Achieved (Stakeholder groups identified, roles defined, initial engagement approaches outlined)

Key performance indicators	*Progress*
Work plan for Phases 2 and 3 defined and integrated	Achieved (Main activities, scope, and out-of-scope items described in Section 2.6)

Table 4-2 Overview milestones

Milestones	*Progress*
Project Kick-off and Inception Meeting	Completed (Prior to deliverable submission)
Initial Stakeholder Workshop/Consultation for Scoping	Completed (As part of Section 2.1.3 engagement approach)
Submission of Phase 1 Draft Deliverable	Completed (Initial draft circulated for internal review)
Completion of preliminary hazard identification and workflow selection	Completed (As per Section 2.2)
Finalization and Submission of Phase 1 Deliverable	Completed (This report, submitted on 07/09/2025)