Deliverable Phase 2 – Climate risk assessment

Advanced Risk assessment for ClimAte resilience Debates, Innovations and Actions in Dobrich (ARCADIA)

Bulgaria, Dobrich

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1. Document Information

Deliverable Title	Phase 2 – Climate risk assessment
Brief Description	The ARCADIA project focuses on conducting a harmonized Climate Risk Assessment (CRA) by applying the CLIMAAX Framework to assess, and prioritise responses to key climate risks affecting Dobrich municipality. Building on the lessons and results of Phase 1, the project advances the multi-risk assessment to integrate local data and develop climate scenarios, with a focus on the most relevant hazards such as river floods, heavy rainfall, urban heatwaves, windstorms, snowfall and blizzards. The ultimate goal is to equip and support local authority and community to develop targeted adaptation strategies that enhance long-term climate resilience. The project utilizes scientific data, local knowledge, and stakeholder engagement to analyse climate hazards, exposure, and vulnerability, enabling a comprehensive understanding of and planning responses to current and future climate risks under different climate scenarios and identifies critical hotspots and vulnerable sectors.
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5. 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
CRA	Climate Risk Assessment
DRBD	Danube River Basin District
DRRP	Disaster Risk Reduction Program
NSI	National Statistical Institute
RIEW	Regional Inspectorate of Environment and Water

6. Executive summary

This deliverable presents the results of Phase 2 of the Climate Risk Assessment (CRA) conducted for Dobrich-city Municipality within the ARCADIA project, applying the harmonised CLIMAAX Framework. Phase 2 was developed to refine, deepen, and prioritise climate risks previously identified in Phase 1, responding to the need for a decision-relevant, forward-looking, and locally grounded multi-risk assessment. The deliverable enables readers to understand, at a glance, which climate risks are most critical for Dobrich, why they matter, and how they inform the next phase of adaptation planning.

Main actions undertaken in Phase 2

Phase 2 focused on advancing the CRA from hazard identification towards risk evaluation and prioritisation. Key actions included:

- confirmation and refinement of priority climate hazards relevant to Dobrich-city Municipality;
- regionalised risk analysis combining hazard, exposure, and vulnerability, supported by local data, scientific modelling, and expert judgement;
- assessment of risk severity, urgency, and local resilience capacity in line with the CLIMAAX Key Risk Assessment Protocol;
- structured stakeholder engagement to validate findings, capture risk perceptions, and contextualise analytical results;
- application of the CLIMAAX Evaluation Dashboard to support transparent and participatory risk prioritisation.

The assessment draws on outputs from Phase 1, harmonised European datasets (including Copernicus-based information), locally available data, and a dedicated stakeholder survey.

Main results and key findings

Phase 2 demonstrates that climate risks in Dobrich-city Municipality are already materialising and are expected to intensify, particularly in relation to heat and extreme precipitation. The key findings are:

- Heatwaves and heavy rainfall / extreme precipitation are identified as the highest priority climate risks. Both hazards combine substantial to critical severity, immediate urgency, and only low to medium resilience capacity, indicating a strong need for near-term and sustained adaptation action.
- Windstorms represent a high-priority risk, characterised by frequent occurrence, city-wide exposure, and strong compound effects when combined with heavy rainfall.
- River flooding and snowfall and blizzards remain relevant but are assessed as medium-priority risks, reflecting their more episodic nature, spatially limited impacts, and relatively stronger existing management capacity.
- The assessment highlights the importance of compound and cascading risks, particularly the interaction between heavy rainfall, windstorms, and urban infrastructure vulnerabilities.
- Stakeholder engagement confirms the practical relevance of the analytical results, while also revealing gaps between risk awareness and preparedness, especially regarding response measures and evacuation planning.
- Resilience capacity across hazards is uneven: while operational response systems exist, escalating and systemic risks—especially heatwaves and extreme precipitation—are increasingly straining existing institutional, infrastructural, and social capacities.

Short conclusions and key take-away messages

Phase 2 successfully delivers a clear, prioritised, and decision-relevant climate risk profile for Dobrich-city Municipality. The application of the CLIMAAX methodology enabled a transition from hazard-based analysis to an integrated evaluation of severity, urgency, and capacity, supporting transparent prioritisation of climate risks. The assessment confirms that climate change represents a concrete and local challenge, affecting public health, infrastructure, services, and economic activity, and requiring targeted and timely adaptation measures.

Plans for the final phase (Phase 3)

Building on the prioritised risks identified in Phase 2, Phase 3 will focus on adaptation planning. It will identify, assess, and structure feasible and locally relevant adaptation measures, engage stakeholders in refining policy options, and support the integration of CRA results into municipal strategies and investment planning. Phase 3 will not revisit detailed hazard modelling, but will concentrate on actionable pathways addressing the most critical risks identified in this deliverable.

1 Introduction

1.1 Background

Dobrich municipality, part of Dobrich District within the Northeast (NUTS2) planning region of Bulgaria covers 109.02 km², making it the smallest municipality by territory in Dobrich District. The terrain is predominantly flat to slightly rolling, part of the Dobrudzha plateau, with elevations ranging from 191 to 350 meters above sea level. The northern parts are lower than the southern periphery, influencing the Dobrichka River's flow pattern.
The municipality experiences a moderate continental climate with an annual average temperature of 10.2°C. July is the warmest month (21.1°C). The precipitation is about 540 mm, concentrated primarily in May and June. Maximum daily rainfall can reach 205.16 mm under extreme conditions (0.1% probability). Northwestern winds dominate, occasionally reaching speeds of up to 20 m/s.
The Dobrichka River, a right tributary of the Suhata River within the Danube river basin traverses the municipality. The river exhibits a highly variable hydrological regime characterized by long dry periods punctuated by short but potentially intense flood events.
Demographically, Dobrich has experienced significant fluctuations, growing substantially between 1946 and 1992 to approximately 125,000 inhabitants before declining to approximately 77,000 inhabitants by 2024 (NSI).
Economically, the municipality combines a strong agricultural base with diverse industries, where food processing accounts for over half of industrial production, complemented by light manufacturing and engineering sectors.

1.2 Main objectives of the project

The second phase of ARCADIA aims at extension and refinement of the climate risk assessment (CRA) carried out in Phase 1 providing Dobrich municipality with a robust, evidence-based understanding of its most relevant climate risks. The main aim has been to conduct the best possible climate change multi-risk assessment of the most relevant climate-related risks for Dobrich municipality, incl. river floods, heavy rainfall, urban heatwaves, and windstorms. Building on the scoping and risk screening conducted in Phase 1, this phase focused on the quantitative analysis and prioritisation of selected climate hazards that pose the greatest threat to the municipality's population, economy, infrastructure and ecosystems.

By applying harmonised CLIMAAX workflows and evaluating risks based on severity, urgency, and resilience capacity, as prescribed by the CLIMAAX Key Risk Assessment Protocol and supported by maps, tables and an evaluation dashboard, the project's Phase 2 enables the municipality to get a better understanding of these risks which necessitate immediate actions as well as long-term adaptation planning. Phase 2 also contributes to strengthening the link between climate risk assessment and local policy implementation at the level of spatial planning, infrastructure investment, disaster risk reduction measures, and sectoral strategies. The application of the Phase 2 of the CLIMAAX handbook has ensured that the project followed a clear, coherent and replicable CRA process adapted to the specific context of Dobrich municipality. The objective was not to assess all possible climate hazards, but to deliver a focused and decision-relevant multi-risk assessment targeting those risks requiring the most urgent and strategic attention.

The rationale of Phase 2 has been to establish the exposure of the municipality to the climate hazards as well as to provide the municipal administration with relevant and actionable information that could feed into disaster prevention and climate adaptation planning decisions. Overall, Phase 2 significantly strengthens the municipality's capacity to understand and manage climate risks by moving beyond hazard-only analysis towards an integrated assessment of impacts, vulnerabilities and adaptive capacity. The results provide a solid analytical foundation for Phase 3, where the focus will shift towards identifying and prioritising feasible adaptation measures that directly respond to the risks and vulnerabilities identified in Dobrich municipality. Thus, the combination of the benefits of the CLIMAAX methodological approach and datasets with locally collected data provides a sound scientific basis for practical application of the assessment. By incorporating higher-resolution local datasets and applying the CLIMAAX Toolbox the analysis generated hazard and risk outputs tailored to the local characteristics of Dobrich municipality.

1.3 Project team

The ARCADIA project team combines high-level scientific and legal expertise with local knowledge. The team consists of: project manager responsible for overall project management, control and reporting functions - Pavel Pavlov - deputy mayor; financial expert - Petia Dimitrova; environmental and climate expert - prof. Nelly Hristova (Climate, Atmosphere and Water Research Institute from the Bulgarian Academy of Science); municipal expert responsible for data collection, communication activities, coordination of information with external services - Miroslava Raynova. “D and D Consulting” Ltd has been procured to support the municipality with technical and legal expertise.

1.4 Outline of the document's structure

This document is structured in accordance with the CLIMAAX deliverable template and follows the logical sequence of the CLIMAAX Common Methodology Framework. The introductory section provides background information on Dobrich municipality and outlines the project objectives, scope and organisational setup. Section 2 presents the Climate Risk Assessment for Phase 2, focusing on the risk analysis and risk evaluation steps of the CLIMAAX methodology. This section describes the refinement and application of selected priority hazard workflows for Dobrich municipality, the climate scenarios considered, and the datasets and models used. It presents the resulting hazard and risk outputs, including maps, tables and indicators derived from the regionalised risk analysis. The subsequent sub-sections summarise the Key Risk Assessment findings, including the assessment of current and future risk severity, urgency and resilience capacity, and the use of the evaluation dashboard to support risk prioritisation.

The final sections of the document present the main conclusions of Phase 2, reflect on progress achieved and remaining limitations, and outline the planned activities for Phase 3, with a focus on the identification and assessment of potential climate adaptation options.

2 Climate risk assessment – phase 2

2.1 Scoping

The scoping phase defines the overall framing of the Climate Risk Assessment (CRA) conducted in Phase 2 of the CLIMAAX project for Dobrich-city Municipality. It establishes the objectives of the assessment, clarifies the local context in which climate risks are addressed, identifies relevant stakeholders and risk ownership arrangements, and explains how key CLIMAAX principles and stakeholder engagement processes were applied. This scoping provides the foundation for the subsequent steps of risk exploration, regionalised risk analysis, and risk prioritisation.

2.1.1 Objectives

The objective of the Phase 2 Climate Risk Assessment for Dobrich-city Municipality is to refine and deepen the understanding of climate-related risks previously identified during Phase 1, by integrating locally relevant data, stakeholder knowledge, and future-oriented scenarios in line with the CLIMAAX framework.

Phase 2 builds on the initial scoping and screening by improving the spatial and thematic resolution of the analysis and by strengthening the assessment of interactions between climate hazards, exposure, and vulnerability. The assessment aims to support informed decision-making at municipal level by providing a structured evaluation of risk severity, urgency, and resilience capacity, enabling the prioritisation of climate risks relevant for policy development, planning, and investment.

The CRA is intended to contribute to municipal climate adaptation efforts, sectoral planning processes, and emergency preparedness, while ensuring coherence with regional, national, and European climate resilience objectives.

The assessment is subject to certain limitations, including the availability and resolution of local data, gaps in historical loss and damage information at municipal scale, and varying levels of stakeholder engagement across sectors. These constraints are addressed through the use of harmonised European datasets, scenario-based analysis, and qualitative validation through stakeholder consultations. Identified uncertainties and data gaps are explicitly acknowledged in the relevant sections of the assessment.

2.1.2 Context

Historically, climate hazards and related impacts in Dobrich-city Municipality have been addressed primarily through sector-specific and reactive measures, such as emergency response planning, infrastructure maintenance, and civil protection mechanisms. These approaches have largely focused on individual hazards and past events, with limited integration of forward-looking climate change scenarios or systematic consideration of compound and cascading risks.

Formal climate risk assessments at municipal level have been limited in scope and depth, often relying on historical observations rather than comprehensive, scenario-based analyses. As climate variability and extreme events intensify, this approach has become increasingly insufficient to support strategic planning and long-term resilience.

The CLIMAAX project addresses this gap by providing a harmonised and forward-looking framework for climate risk assessment that situates local challenges within a broader regional, national, and European context. Dobrich-city Municipality is exposed to multiple climate hazards affecting key sectors such as public health, transport, urban infrastructure, energy supply, and emergency services. Although the relevance and magnitude of these hazards vary, their combined and interacting effects pose growing challenges for municipal governance and service provision.

The Phase 2 CRA is conducted within the existing governance and policy context, including national climate adaptation and disaster risk management frameworks and municipal development strategies. It aims to strengthen the evidence base for future adaptation measures and improve alignment between local risk understanding and policy objectives at different governance levels.

2.1.3 Participation and risk ownership

The map of the relevant stakeholders could be present through a three-layer structure

1. Strategic and normative oversight.

At the strategic level, the Municipal Council of Dobrich acts as the legislative and oversight body responsible for adopting key policy documents that define risk governance and acceptable levels of risk, including:

- Municipal Disaster Risk Reduction Programme (2021–2025);
- Municipal Disaster Protection Plan (2019);
- Evacuation and Dispersal Plan (2015).

This level defines strategic objectives, allocates resources, and provides political oversight of risk management policies.

2. Executive and competent authorities. This layer includes institutions responsible for risk identification, assessment, preparedness, and response, operating through formal coordination mechanisms and data exchange.

Table 2.1 Stakeholder mapping and organigram

Institution	***Key Responsibility***
Dobrich municipality administration & council	Local governance, funding, and general administrative coordination.
Regional Directorate Fire Safety & Population Protection	Direct emergency response, rescue operations, and fire management.
Danube River Basin Directorate	Flood risk assessment and water management strategies.
NIMH	Early warning systems for weather (snow/ice) and hydrologic events.

Regional Health Inspectorate (RHI)	Public health safety, sanitation post-disaster, and disease control.
Water Supply & Sanitation	Maintaining critical infrastructure for water and sewage during crises.
Regional Inspectorate of Environment and Water	Monitoring pollution and environmental impact of disasters.

3. Community and economic stakeholders:

This layer includes actors directly affected by climate risks and involved in resilience-building:

- Civil society organizations: “Citizens+”, “Dobrodzhantzi”, “Black Sea Centre of Excellence”;
- Educational institutions: vocational and professional high schools, including the Professional High School of Agricultural Economy;
- Businesses and industry: Start JSC (MONBAT Group), Neoperl Bulgaria EOOD, Oliva AD, Akumplast JSC, Esseterre Bulgaria EOOD;
- Residents and vulnerable groups, particularly those in flood-prone or structurally vulnerable areas.

Stakeholder involvement in Phase 2

Stakeholder involvement in Phase 2 of the ARCADIA (CLIMAAX) project focused on expanding participation and deepening engagement compared to Phase 1, with the aim of refining the climate risk assessment, validating preliminary results, and capturing local risk perceptions and priorities.

Engagement activities included: a structured stakeholder survey (46 respondents) targeting municipal administration, agriculture, tourism, and related sectors; bilateral consultations with competent authorities; preparatory coordination for a multi-stakeholder workshop that will organized on January 28, 2026 (https://www.dobrich.bg/bg/novini/obshtina-grad-dobrich-kani-zainteresovani-strani-na-seminar-za-obsazhdane-na-klimatichnite-riskove-i-adaptatsionni-merki), where Phase 2 results will be presented and discussed.

The risk ownership in Dobrich municipality is organised according to a multi-level governance model:

- Identification and monitoring of risks: NIMH, Danube River Basin Directorate, RIEW municipal administration;
- Risk assessment and prioritisation: Municipality, supported by national institutions and CLIMAAX methodologies;
- Risk mitigation and preparedness: Municipal administration in cooperation with Fire Safety & Population Protection and sectoral operators;
- Emergency response: Regional Directorate Fire Safety & Population Protection, RHI.

Vulnerable groups and exposed areas: Key vulnerable groups include: socially disadvantaged households located along the Dobrichka River; small and medium-sized enterprises in the Northern Industrial Zone; residents of the old city quarter hosting schools and health facilities; commuters exposed to snow, ice, and wind-related transport disruptions.

Acceptable and tolerable risk levels: Dobrich municipality does not currently apply formally defined quantitative thresholds for acceptable or tolerable climate risk. Initial information on risk perception and tolerance has been collected through the survey with stakeholders conducted in Phase 2. Further validation and discussion of acceptable risk levels are planned through the stakeholder workshop scheduled for January 28, 2026, supporting future prioritisation of adaptation measures.

2.1.4 Application of principles

The Phase 2 Climate Risk Assessment was conducted in accordance with the core principles of the CLIMAAX framework. Considerations of social justice, equity, and inclusivity were incorporated through attention to vulnerable populations and differential exposure across urban areas. Quality, rigour, and transparency were ensured through the use of harmonised datasets, clearly documented assumptions, and traceable data sources. A precautionary approach was applied by integrating scenario-based analysis to address uncertainty and explore plausible future climate developments.

2.1.5 Stakeholder engagement

The project team focused its efforts in the Phase 2 on expanding the number and profile of the stakeholders engaged in the project. A targeted structured survey with 46 returned questionnaires assessing local perceptions and priorities was conducted. The survey aimed to assess perceptions of climate risks, levels of awareness, and readiness for adaptation at the local level. The questionnaire consisted of four thematic parts, including 20 closed-ended questions, with multiple answer options for some questions to capture the complex nature of climate impacts.

Findings from the stakeholder survey: The survey of 46 local stakeholders provided insights into perceived risks, impacts, and adaptation priorities, which directly informed the risk assessment.

Respondent profile: the survey includes respondents predominantly from the municipal administration (63.0%) and the agriculture and tourism sectors. These respondents are directly involved in infrastructure management, disaster response planning, and policy implementation. 82.6% of all respondents have lived and/or worked in Dobrich for over 10 years, ensuring a high level of local knowledge of climate events and risks.

The answers to the questionnaire show that the Dobrich municipality is well aware of the main climate risks (winds, floods, heatwaves). There is high public awareness of the city's natural hazards, but insufficient information on crisis response and scepticism about the administration's full preparedness. It means that the municipality should direct attention and resources to modernising drainage systems and the early warning system, creating green areas, conducting information campaigns on evacuation routes, signals, and actions in case of disasters, and implementing measures to combat heat stress.

The participants in the survey and other stakeholders who will be involved in the workshops, meetings and final conference of the project will get enhanced awareness of climate risks and vulnerabilities in the Dobrich municipality and could participate in the decision-making for prioritizing climate resilience in municipal strategic documents and investments. The final events of the project will aim at empowering local communities through engagement and collaboration for implementing the project outcomes in their activities.

The key challenge will be to translate the high-level scientific and technical outcomes into simple messages which could explain to the local administration, business and citizens the urgency of climate adaptation policies and actions.

2.2. Risk Exploration

Risk exploration in Phase 2 builds on the initial screening conducted during Phase 1 of the CLIMAAX project and focuses on refining the understanding of climate-related risks relevant to Dobrich-city Municipality. Rather than repeating the full screening process, this phase concentrates on confirming the relevance of previously identified hazards, incorporating updated information where available, and preparing the basis for a more detailed regionalised risk analysis.

The risk exploration step considers the interaction between climate hazards, exposure, and vulnerability, informed by stakeholder input and available data sources. Particular attention is given to changes in risk relevance under future climate conditions and to the identification of risks that require prioritisation in subsequent assessment steps.

2.2.1. Screen risks (selection of main hazards)

Compared to the first deliverable, the main development in the risk screening step is the shift from a predominantly single-hazard focus on river flooding towards a broader multi-hazard perspective that reflects stakeholder perceptions, observed climate impacts, and recent climate trends in Dobrich-city Municipality. While Phase 1 concentrated primarily on river flood risk along the Dobrichka River, Phase 2 confirms floods as a relevant hazard but additionally identifies heavy (torrential) rainfall, urban heatwaves, strong winds and windstorms, and winter extremes as climate-related risks requiring systematic assessment.

The exclusion of drought as a standalone risk in this phase reflects the urban character of Dobrich-city Municipality, which contains only limited agricultural land. Agricultural drought impacts are more relevant for Dobrich-rural Municipality, which is administratively distinct despite surrounding the city, and are therefore outside the scope of the present urban-focused climate risk assessment.

Relevant climate hazards and associated risks

Based on observed impacts, modelling results, stakeholder feedback, and available literature, the following climate hazards are relevant for Dobrich-city Municipality:

- **River and pluvial floods**, caused by intense rainfall and river overflows, leading to street flooding, damage to buildings and critical infrastructure, disruption of transport and public services, and potential threats to life and property, particularly in low-lying urban areas and industrial zones.
- **Heavy (torrential) rainfall**, which overloads drainage systems, generates rapid surface runoff, causes localised urban flooding, and accelerates the deterioration of roads and public infrastructure.
- **Urban heatwaves**, characterised by summer temperatures exceeding 35°C, posing health risks for elderly people, children, and individuals with chronic illnesses, reducing labour productivity, and increasing demand for health and social services.

- **Strong winds and windstorms**, which cause material damage to roofs, facades, and trees, trigger power outages, block streets, and increase safety risks in densely built areas.
- **Heavy snowfall, ice, and blizzards**, which periodically disrupt mobility, supply chains, and access to essential services, placing additional pressure on emergency and maintenance services.

Current situation and spatial exposure

The current risk situation in Dobrich-city Municipality reflects exposure to multiple hazards with distinct spatial patterns:

- **River and pluvial floods**
    - Documented flood events, most notably in 2014.
    - Modelled scenarios indicate significant inundation depths in central and southern parts of the city for higher return periods.
    - Highest exposure along the Dobrichka River corridor, adjacent low-lying neighbourhoods (including parts of the historic old quarter), and the Northern industrial zone.
- **Heavy rainfall**
    - Frequent cloudbursts causing localised flooding.
    - Streets and junctions with insufficient drainage are particularly affected.
- **Heatwaves**
    - Affect the entire municipal territory.
    - Strongest impacts in densely built urban areas with limited green infrastructure.
- **Strong winds, storms, snow, and ice**
    - Primarily affect built-up areas with high densities of buildings, trees, power lines, and transport infrastructure.
    - Main roads and access routes to industrial and service areas are especially exposed.

Exposed and vulnerable groups

Exposure and vulnerability differ across population groups and sectors:

- Residents in flood-prone and low-lying neighbourhoods, including socially disadvantaged groups near the Dobrichka River and in parts of the old quarter, face higher exposure and often limited resources for prevention and recovery.
- Businesses and small and medium-sized enterprises in the Northern industrial zone and central commercial areas are exposed to flood, wind, and power-outage risks, leading to direct damage and business interruptions.
- Vulnerable groups such as elderly people, children, and individuals with chronic illnesses are particularly sensitive to heatwaves and winter extremes and depend on uninterrupted access to health and social services.
- Critical infrastructure operators (water, energy, transport, health, education) are affected by floods, storms, snow, and ice, with potential cascading effects on the wider community.

Observed hazards and evidence base

Observed climate hazards in Dobrich-city Municipality and the wider Northeast region include:

- **River and pluvial floods**
    - Repeated flooding along the Dobrichka River and its tributaries.

    - Documented events such as the 2014 flood.
    - Modelled scenarios showing water depths of up to 4 m and extensive inundation areas for 100- and 500-year events.
    - Local pluvial flooding during intense rainfall in low-lying urban zones and streets with insufficient drainage.
- **Heavy (torrential) rainfall and convective storms**
    - Very intense rainfall over short periods.
    - Rapid surface runoff, overloaded drainage systems, and flash flooding.
- **Strong winds and windstorms**
    - Frequent exceedance of damage-relevant wind speed thresholds.
    - Fallen trees, roof damage, and interruptions to electricity supply and transport.
- **Heatwaves and high temperatures**
    - Increasing number of summer days with temperatures above 35°C.
    - Intensified heat stress and urban heat island effects.
- **Snow, ice, and blizzards**
    - Periodic winter events disrupting transport, electricity supply, and access to services.

Expected changes according to Copernicus/C3S-type projections

Although the Copernicus Interactive Climate Atlas provides information at European and regional scales rather than municipality level, its projections for Southeast Europe and Bulgaria support the CLIMAAX findings for Dobrich-city:

- **Temperature and heatwaves**
    - Significant increase in mean annual and summer temperatures.
    - More frequent and intense heatwaves and higher night-time temperatures.
    - Longer heatwave periods and intensified urban heat island effects.
- **Precipitation and heavy rainfall**
    - Tendency towards drier average summers combined with an increase in the intensity of extreme precipitation events.
    - Higher risk of flash flooding and urban pluvial floods due to fewer but more intense rainfall events.
- **Wind and storms**
    - Higher uncertainty compared to temperature and precipitation projections.
    - Indications that wind-related extremes associated with convective storms will remain relevant.

Synthesis and justification of selected hazards

The combined analysis of observed impacts, stakeholder feedback, CLIMAAX-based modelling, and regional Copernicus/C3S information confirms the need for a multi-hazard approach to climate risk assessment in Dobrich-city Municipality. Floods (river and pluvial), heavy rainfall, heatwaves, strong winds, and winter extremes emerge as the priority hazards due to their current impacts, projected intensification, and potential for cascading effects across urban systems and critical services.

Data gaps and supporting literature

Significant data gaps remain at municipal level, particularly regarding long-term time series for strong winds, short-duration extreme rainfall, and heatwaves. Contextual information is therefore drawn from national-level assessments and policy documents, including:

- *Analysis and assessment of the risk and vulnerability of sectors in the Bulgarian economy to climate change* (2014)
- *Assessment of the National Disaster Risk Reduction Strategy of Bulgaria* (2020)
- *National Strategy for Disaster Risk Reduction 2018–2030*
- *National Programme for Disaster Risk Reduction 2021–2025*
- *National Disaster Risk Profile and Disaster Risk Management Plan*
- *Flood Risk Management Plans 2022–2027*
- *Technical guidance on the climate proofing of infrastructure 2021–2027*
- *Climate Change Mitigation Act* (latest amendments 2025)

Additional sources include Chiotoroiu et al. (2014), Valcheva and Spiridonov (2021), NOAA Dobrich Weather Observation Reports (2019–2023), and hydrological information from the Dobrichka and Suha rivers. As highlighted by McNaught (2024), local-level climate risk assessment is a key tool for integrated planning and decision-making.

Other documented urban flooding events in addition to the one in 2014 caused by torrential rainfall include also 7 August 2009 (91 l/m² in a few hours, affecting the "West" industrial zone) and 3 October 2025, when torrential rain and hail flooded the lowest parts of the city.

2.2.2 Choose Scenario

The selection of scenarios for the Phase 2 Climate Risk Assessment aims to capture plausible future climate conditions relevant to Dobrich-city Municipality and to support a forward-looking evaluation of risk. The analysis considers future climate projections consistent with established European climate datasets and scenarios, allowing comparison with current conditions and exploration of potential changes in risk magnitude and distribution.

Future climate conditions were selected to reflect mid- to long-term time horizons relevant for municipal planning and infrastructure investment. These time horizons enable the assessment of both near-term risks requiring immediate attention and longer-term trends that may influence strategic adaptation decisions.

Socio-economic developments were considered qualitatively, taking into account expected trends such as population dynamics, urban development patterns, and changes in demand for public services. These factors were combined with future climate conditions to contextualise exposure and vulnerability, rather than being modelled as independent scenarios.

The integration of future climate and socio-economic considerations provides a coherent framework for assessing how climate risks may evolve over time and supports the prioritisation of risks under conditions of uncertainty. Assumptions and limitations related to scenario selection are documented in the relevant hazard-specific sections of the regionalised risk analysis.

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2.3. Regionalized Risk Analysis

2.3.1. Hazard #1 - Heatwaves: fine-tuning to the local context of Dobrich municipality

The regionalised risk analysis for heatwaves confirms that extreme heat represents one of the most significant climate risks for Dobrich-city Municipality under both current and future climate conditions. The detailed hazard, exposure, and vulnerability assessment, including spatial analysis and risk mapping, is presented in Annex 1.

The analysis shows that heatwave exposure is widespread across the entire urban territory, with particularly high exposure in densely built neighbourhoods characterised by extensive sealed surfaces, limited vegetation, and pronounced urban heat island effects. Spatial modelling identifies fragmented but recurrent hotspots of elevated land surface temperature, which largely coincide with areas of high population density.

Vulnerability to heatwaves is socially differentiated. The most affected groups include elderly residents, people with chronic cardiovascular and respiratory diseases, children, and socially isolated individuals. These groups are disproportionately concentrated in central neighbourhoods and large housing estates, where high exposure and high vulnerability overlap. As a result, heat stress risk is not only spatially uneven but also socially stratified.

Observed meteorological data confirm that heatwaves are a regular summer phenomenon in Dobrich, with multiple episodes per year typically lasting three to four consecutive days and maximum temperatures frequently exceeding 35°C. These observations correspond well with Copernicus-based heat exposure maps and indicate that modelled high-risk zones reflect real conditions, which may be locally even more extreme.

Future projections indicate a clear increase in the frequency, duration, and intensity of heatwaves, including higher night-time temperatures that reduce physiological recovery. This trend significantly increases the likelihood of cumulative health impacts and places growing pressure on healthcare services, emergency response systems, and energy supply due to increased cooling demand.

Overall, the heatwave risk for Dobrich-city Municipality is assessed as high, driven by an intensifying hazard, city-wide exposure, and significant vulnerability among specific population groups. Heatwaves therefore represent a priority risk for subsequent evaluation and adaptation planning within the CLIMAAX framework.

(Detailed datasets, maps, and quantitative results are provided in Annex 1.)

2.3.2. Hazard #2 - Extreme precipitation: fine-tuning to the local context of Dobrich municipality

The regionalised risk analysis for heavy rainfall and extreme precipitation identifies this hazard as one of the most critical climate risks for Dobrich-city Municipality, due to its strong potential to generate flash floods, surface runoff, and systemic disruption of urban infrastructure. The full technical analysis, including statistical modelling, return period assessment, and spatial risk mapping, is presented in Annex 1.

The assessment distinguishes between short-duration, high-intensity rainfall events (3-hour extremes) and longer-duration precipitation exceeding 50 mm within 24 hours, as both types are highly relevant for urban flooding processes in Dobrich. Results show that extreme short-term rainfall events exhibit high interannual variability but recur with sufficient frequency to pose a persistent risk. Rainfall exceeding 20–25 mm within three hours is identified as a critical threshold, as it triggers rapid surface runoff and flash flooding in densely built areas with limited infiltration capacity.

For longer-duration events, the analysis indicates a pronounced shortening of return periods under future climate conditions. Precipitation events that historically occurred once every 20–25 years are projected to occur as frequently as every 5–10 years in the mid-21st century. This represents a substantial increase in hazard frequency and directly challenges the design standards of existing drainage and flood protection infrastructure.

Exposure to extreme precipitation is high and spatially widespread across the municipality. Due to the relatively homogeneous spatial distribution of intense rainfall, all urban areas are affected, with particularly high exposure in low-lying neighbourhoods, areas with sealed surfaces, transport underpasses, and zones with ageing or undersized drainage systems. Public buildings, residential basements, commercial facilities, and industrial areas are especially susceptible to surface flooding.

Vulnerability is assessed as moderate to high, reflecting both physical and systemic factors. The existing urban drainage network was largely designed for lower-intensity events and lacks sufficient capacity to manage increasingly frequent torrential rainfall. The limited presence of natural retention areas and blue-green infrastructure further amplifies runoff generation. Vulnerability is particularly pronounced for ground-floor residents, small businesses, and critical urban services, where even short disruptions can lead to significant economic and social impacts.

The combined assessment of hazard, exposure, and vulnerability results in a high to critical risk level for heavy rainfall and extreme precipitation in Dobrich-city Municipality. For 3-hour extreme rainfall, the risk is assessed as high, driven by the likelihood of infrastructure overload and disruptive flash floods. For precipitation exceeding 50 mm within 24 hours, the risk reaches a critical level, as the projected increase in frequency poses a systemic threat to urban infrastructure, public safety, and economic stability.

Observed flood events linked to torrential rainfall, including documented cases from 2009, 2014, and 2025, confirm that these risks are not theoretical but already materialising. The analysis therefore highlights heavy rainfall and extreme precipitation as a priority hazard requiring urgent consideration in risk prioritisation and adaptation planning under the CLIMAAX framework.

(Detailed modelling results, figures, tables, and event-based analyses are provided in Annex 1.)

2.3.3. Hazard #3 - Windstorm: fine-tuning to the local context of Dobrich municipality

The regionalised risk analysis identifies windstorms and strong wind events as a major climate risk for Dobrich-city Municipality, particularly due to their high frequency, urban-wide exposure, and strong potential for compound and cascading impacts when combined with heavy rainfall. The detailed hazard analysis, observational data, and risk assessment are provided in Annex 1.

Observed meteorological data for the period 2019–2023 demonstrate that strong winds are a recurrent phenomenon in Dobrich, with wind gusts exceeding 50 km/h recorded in all analysed years and accounting for a substantial share of events. Although full storm conditions (≥70 km/h) occur less frequently, their occurrence confirms the municipality’s exposure to potentially high-impact wind events. Strong winds show a clear seasonal pattern, with peaks in late winter–early spring and late summer–early autumn, and are often associated with convective storms.

Exposure to windstorms is very high across the entire urban territory, reflecting the flat terrain of Dobrich and the dense concentration of exposed assets. Particularly affected elements include residential buildings (especially roofs, facades, balconies, and older structures), overhead electricity and communication lines, transport infrastructure, public spaces, and urban greenery. Even wind speeds that formally fall within the “strong wind” category can generate significant disruption in the urban environment due to falling trees, damaged structures, blocked streets, and service interruptions.

Vulnerability is assessed as high, driven by both physical and systemic factors. Ageing infrastructure, extensive overhead utility networks, and mature urban trees increase sensitivity to wind damage. Social vulnerability is also relevant, as power outages and transport disruptions disproportionately affect elderly residents, children, and people dependent on continuous access to health and social services. Importantly, many windstorm events in Dobrich are accompanied by intense rainfall and, in some cases, hail, which significantly amplifies impacts and increases the likelihood of cascading failures.

The combined assessment of hazard, exposure, and vulnerability results in a high to critical windstorm risk for Dobrich-city Municipality. While windstorms alone already pose a substantial risk, their interaction with heavy rainfall transforms them into a compound hazard with potentially severe consequences, including widespread infrastructure damage, urban flooding, prolonged power outages, and disruptions to emergency response.

Stakeholder feedback collected within the CLIMAAX project reinforces these findings, with a large majority of respondents identifying strong winds as a hazard that frequently affects the municipality. The analysis therefore confirms windstorms as a priority risk, closely linked to extreme precipitation, and underscores the need for integrated risk management and adaptation measures addressing both hazards jointly.

(Detailed observational data, event analysis, and risk metrics are provided in Annex 1.)

2.3.4. Hazard #4 - River flooding: fine-tuning to the local context of Dobrich municipality

River flooding is included in the regionalised risk analysis for Dobrich-city Municipality to ensure methodological continuity with Phase 1 of the CLIMAAX assessment and completeness of the multi-hazard framework. The detailed hydrological modelling, flood extent mapping, and quantitative risk estimates are presented in Annex 1 and were initially developed in the Phase 1 Climate Risk Assessment.

Historical flood events recorded in Dobrich (notably in 2009, 2014, and 2025) demonstrate that flooding has occurred repeatedly within the urban area. However, evidence from municipal records, stakeholder feedback, and event descriptions indicates that these floods were primarily triggered by intense and short-duration rainfall, rather than by sustained river discharge exceeding the hydraulic capacity of the Dobrichka River under normal conditions. In this context, flooding is best characterised as a combined pluvial–fluvial phenomenon, in which extreme precipitation generates rapid surface runoff that interacts with the river system.

The Dobrichka River passes through the city in a largely regulated concrete channel, which under maintained conditions is generally capable of conveying typical flood flows. Localised flooding is therefore strongly influenced by secondary and modifiable factors, including insufficient maintenance of the riverbed and riparian vegetation, temporary blockages by debris, limited soil permeability due to extensive sealed surfaces, and reduced capacity of urban drainage systems caused by clogged inlets or ageing infrastructure. Low-lying urban areas with high impervious cover are particularly susceptible to these processes.

Despite this, hydrodynamic modelling undertaken in Phase 1 and refined in Phase 2 demonstrates that high-impact river flooding cannot be fully excluded, particularly under low-probability, high-magnitude events. Model results indicate increasing flood depths and spatial extent for higher return periods (50-, 100-, and 500-year events), with potential impacts extending into central neighbourhoods and the Northern industrial zone. Under future climate scenarios, projected increases in extreme rainfall intensity further amplify these worst-case outcomes.

Exposure to river flooding is therefore spatially concentrated rather than city-wide, affecting areas adjacent to the Dobrichka River and downstream low-lying zones. Vulnerability is assessed as moderate to high, driven by the concentration of residential buildings, commercial assets, and critical infrastructure near the river corridor, as well as the potential need for evacuation in areas experiencing flood depths exceeding 1.0 m. Quantitative estimates of potential economic damage and population exposure, as presented in Annex 1 and Phase 1, represent upper-bound scenarios that are relevant for long-term risk awareness and strategic planning.

Overall, the river flooding risk for Dobrich-city Municipality is assessed as moderate to high, with critical impacts limited to extreme and low-probability scenarios. In contrast to heatwaves and extreme precipitation, river flooding is less frequent and more dependent on local management conditions. Nevertheless, its inclusion remains justified due to its interaction with heavy rainfall, the potential for severe impacts under adverse conditions, and its relevance for emergency preparedness and long-term resilience planning.

The assessment indicates that effective maintenance, drainage management, and nature-based or technical mitigation measures could substantially reduce river-related flood risk, underscoring the importance of proactive urban water management alongside climate adaptation strategies.

(Detailed modelling results, flood maps, and quantitative risk estimates were provided in the Phase 1 CLIMAAX Deliverable and are summarized in Annex 1 to the present report.)

2.3.5. Hazard #5 - Snowfall and blizzard

Snowfall, ice, and blizzard conditions constitute a recurrent but episodic climate risk for Dobrich-city Municipality, primarily affecting transport, access to services, and the continuity of critical urban functions during winter periods. The detailed hazard characterisation, exposure analysis, and supporting data are presented in Annex 1.

Observed winter conditions in Dobrich include periodic episodes of heavy snowfall, strong winds combined with snow (blizzards), and ice formation. While such events do not occur every winter, when they do occur they tend to generate short-term but high-impact disruptions, particularly affecting road transport, public transport services, electricity supply, and access to healthcare and emergency services. Historical experience and stakeholder feedback indicate that even relatively short-lived events can have disproportionate impacts on urban mobility and safety.

Exposure to snowfall and blizzards is city-wide, as all neighbourhoods rely on the same transport network, utility services, and emergency response systems. Certain elements are particularly exposed, including main road corridors, access routes to industrial and service areas, public transport lines, and overhead electricity and communication infrastructure. Pedestrian areas and secondary streets are also vulnerable, especially when snow removal is delayed or incomplete.

Vulnerability is assessed as moderate, but with clear social and functional dimensions. Elderly people, people with disabilities, and individuals dependent on regular access to medical and social services are especially affected during winter extremes. Urban services responsible for snow removal, road maintenance, and emergency response experience increased operational pressure, and their effectiveness is strongly influenced by preparedness, equipment availability, and response timing.

Climate projections for the region suggest a general tendency towards milder average winter temperatures, but they also indicate that episodic extreme winter events will continue to occur. This implies that while the overall frequency of snow cover may decrease, the risk of disruptive snowfall, ice, and blizzard events remains relevant, particularly when such events coincide with strong winds or rapid temperature fluctuations.

Overall, the risk associated with snowfall and blizzards in Dobrich-city Municipality is assessed as moderate, characterised by low to medium frequency but potentially high short-term impacts. The risk is largely manageable through operational preparedness, including timely snow removal, maintenance of transport and energy infrastructure, and targeted support for vulnerable population groups. Nevertheless, winter extremes remain an important consideration for emergency planning and resilience measures, especially in combination with other hazards such as strong winds.

(Detailed event analysis, supporting data, and maps are provided in Annex 1.)

2.4. Key Risk Assessment Findings

The Key Risk Assessment step translates the outputs of the Risk Analysis into decision-relevant insights by evaluating each identified climate risk in terms of severity, urgency, and local resilience capacity, as displayed in the CLIMAAX Evaluation Dashboard and guided by the Key Risk Assessment Protocol .

This step represents a sense-making and evaluation phase, designed to support structured engagement with stakeholders, experts, and priority groups. Building on the quantitative and qualitative outputs generated in the Risk Analysis (Section 2.3 and Annex 1), the Key Risk Assessment combines analytical evidence with stakeholder knowledge to contextualise risks within the local socio-economic, institutional, and infrastructural setting of Dobrich-city Municipality.

In line with the CLIMAAX methodology, the evaluation process follows an iterative and participatory logic, whereby:

- risk outputs are first gathered and prepared in an accessible format;
- severity is assessed by contextualising potential impacts and losses for the municipality;
- urgency is evaluated based on observed trends, projected changes, and time sensitivity of action;
- resilience capacity is examined to understand existing abilities and gaps in coping with climate risks;
- these three elements are qualitatively integrated to determine risk priority.

Each analysed climate hazard is evaluated individually using a structured dashboard approach, allowing transparent comparison across risks and supporting informed prioritisation. Stakeholder input does not replace analytical evidence but is used to validate, contextualise, and enrich the evaluation, consistent with the participatory principles of the CLIMAAX framework.

The results of this Key Risk Assessment provide the basis for identifying priority climate risks that require targeted attention in subsequent climate risk management, adaptation planning, and monitoring and evaluation steps.

2.4.1 Mode of engagement for participation

The engagement and participation process in Phase 2 of the project built upon the stakeholder identification and consultation activities described in Section 2.1.5. In this phase, stakeholder engagement focused specifically on the evaluation of climate risks, including their perceived severity, urgency, and the local capacity to respond, in line with the CLIMAAX Key Risk Assessment Protocol.

Stakeholder feedback generally confirmed the prioritisation of the main climate risks and supported the analytical results of the regionalised risk assessment. In several cases, stakeholder perspectives highlighted higher perceived urgency and severity, particularly in relation to critical infrastructure and service disruption, reinforcing the final risk evaluation. Where differences between analytical outputs and stakeholder perceptions emerged, these were documented and used to contextualise the results rather than to override evidence-based findings.

The CLIMAAX Key Risk Assessment dashboard served as a facilitating tool for dialogue, enabling transparent discussion of trade-offs, uncertainties, and priorities. This participatory approach strengthened the legitimacy of the risk evaluation and ensured that the outcomes are understandable, relevant, and usable for decision-making and for the subsequent adaptation planning phase.

As described in Section 2.1.5, a survey-based method was applied to engage stakeholders and assess their perceptions of climate risks, levels of awareness, and readiness for local adaptation.

Stakeholder perceptions of climate hazards

Survey results indicate that respondents associate climate risks in Dobrich municipality with both summer and winter phenomena. Some hazards identified by respondents, such as fog, frost, and ice, are not directly driven by climate change but are perceived as disruptive due to their impact on transport and daily activities. An unexpectedly high share of respondents identified fog as a concern, reflecting local experience rather than climate change attribution.

When asked to assess climate hazards as moderate risks, floods (41.3%), droughts (39.1%), torrential rains (28.1%), and heatwaves (26.1%) were identified as causing significant concern. The relatively high concern for droughts contrasts with the urban character of Dobrich-city Municipality, while heatwaves were assessed as a moderate risk by a lower share of respondents than expected.

In response to the question *"Which climate hazards have the most significant impact on your health and comfort?"*, heatwaves (50%), temperature fluctuations (48%), and prolonged cold (37%) were identified as the main sources of discomfort and health risk. Strong winds were also reported as having a significant impact on health and comfort by 39% of respondents, likely due to dust emissions. High air pollution was reported as a serious problem by 33% of participants, while high humidity and fog were indicated by the fewest respondents (22%).

Occupational risk perception and sectoral vulnerability

Responses to the question *"What meteorological phenomena are most dangerous for your professional activity?"* show a strong consensus that floods represent the most hazardous systemic risk for professional activities in Dobrich municipality, with 69.6% of respondents identifying them as such. Icefalls were ranked second (41.3%), followed by fires (30.4%) and strong winds (28.3%). Peripheral occupational risks include droughts and hailstorms (13.0% each).

Sectoral vulnerability is perceived as highest for floods, strong winds, droughts, hailstorms, and fires, particularly in the tourism and services sectors. These perceptions reflect both direct exposure and the sensitivity of economic activities to service disruption.

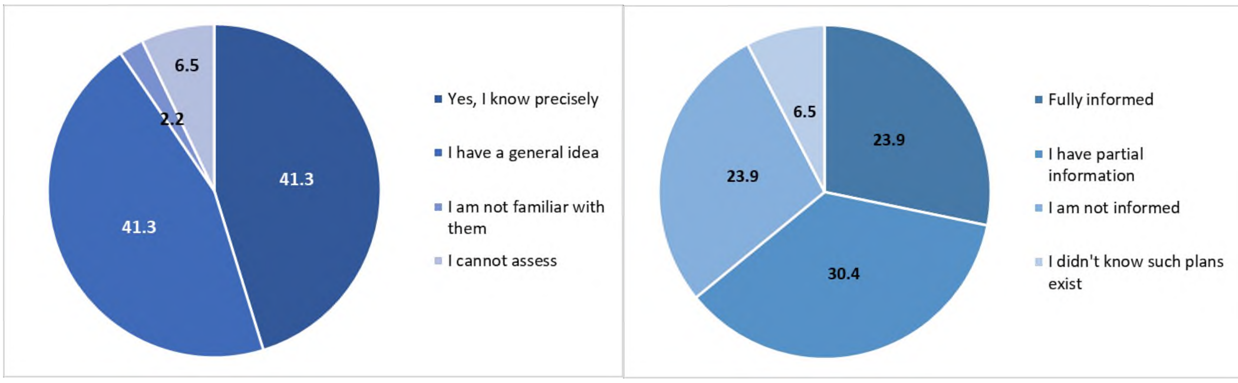
When respondents were asked about direct losses and damages, a notable gap emerged between perceived risk and experienced impacts. While 69.6% perceive floods as a major risk, only 15.2% reported having suffered actual flood-related damage. In contrast, 23.9% reported damage caused by strong winds, making wind-related impacts the most commonly experienced type of material damage, likely due to their visibility. Agriculture was identified as the most affected economic sector, with 23.9% reporting losses in agricultural production. Hail damage was reported by 13.0% of respondents.

Overall, the results suggest that strong winds are assessed most realistically, while floods and fires tend to be overestimated in terms of perceived damage compared to actual losses.

Awareness of flood risk and preparedness

Responses to questions on flood risk awareness indicate a high level of general awareness among residents of Dobrich. A total of 82.6% of respondents report being aware of flood risk zones, and 41.3% know exactly which areas are at the highest risk (Figure 2.1a). This suggests that flooding is a well-recognised hazard in the municipality.

However, awareness of evacuation plans is more limited. While many respondents have heard that such plans exist, fewer are familiar with their content. In total, 23.9% report being uninformed, and 30.4% indicate complete unpreparedness (Figure 2.1b).



a) b)

Figure 2.1 Answers to the questions: a) "Do you know which areas in the city of Dobrich have the highest risk of flooding?"; b) "Are you aware of the flood evacuation plans?"

Based on responses related to risk awareness and response knowledge, three groups can be identified within the municipality:

- Group 1: "Knows the risk and the response" (23.9%), including professionals and residents of high-risk areas;
- Group 2: "Knows the risk but not the response" (approximately 50%), representing a key target group for education and capacity-building;
- Group 3: "Knows neither the risk nor the response" (8.7%), representing the most vulnerable group.

Perceived frequency of hazards and trust in institutional capacity

Results related to the perceived frequency of climate hazards indicate that strong winds and storms are considered the most frequent climate-related phenomena affecting Dobrich municipality (Figure 2.2). Recorded wind speeds typically range between 14–19 m/s (50–69 km/h), with gusts reaching up to 24 m/s (90 km/h), and an average annual occurrence of 5–20 days (National Institute of Meteorology and Hydrology, Varna Branch).

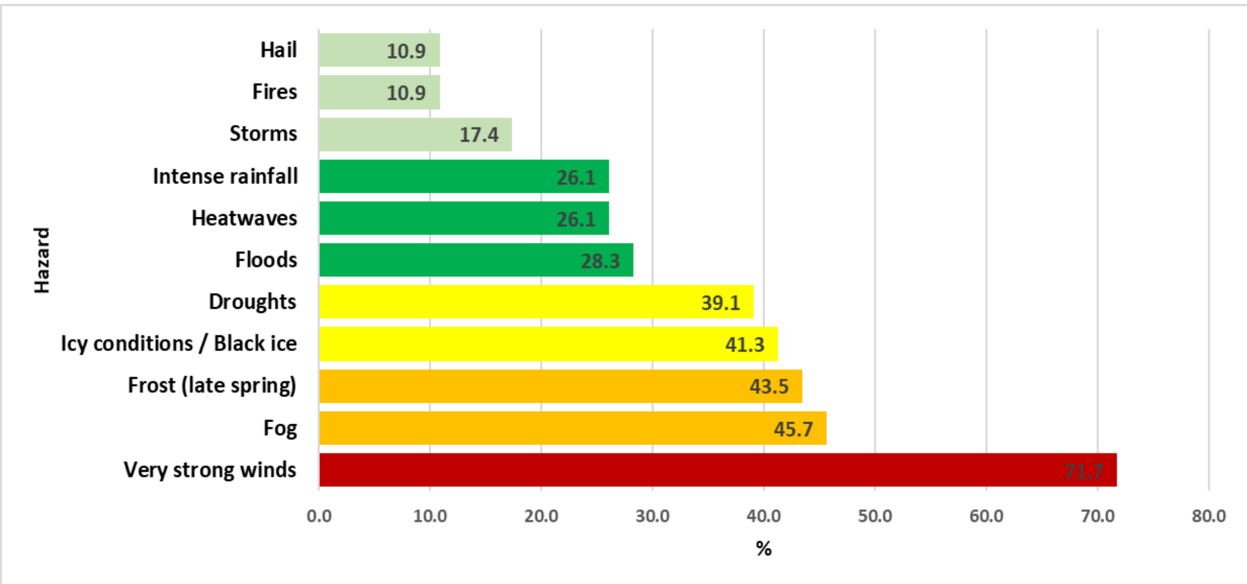


Figure 2.2 Answers to the question "Which climate hazards most frequently affect your area?"

Trust in institutional preparedness is assessed as **moderate to low**. Only 28.3% of respondents believe that the municipal administration is fully prepared to respond to climate-related disasters. Almost half of respondents (45.3%) consider preparedness to be partial, indicating recognition of existing capacity alongside perceived gaps.

Priorities for risk reduction measures

When asked *"What measures are necessary to reduce climate risks in your municipality?"*, respondents identified **infrastructure improvement** as the dominant priority (78.3%). Other frequently selected measures include improved early warning systems (52.2%), educational campaigns (37.0%), and increased green spaces (39.1%) (Figure 7.4). Support for sustainable agriculture was indicated by only 15.2% of respondents, reflecting its lower relevance as a city-wide priority despite being an affected sector.

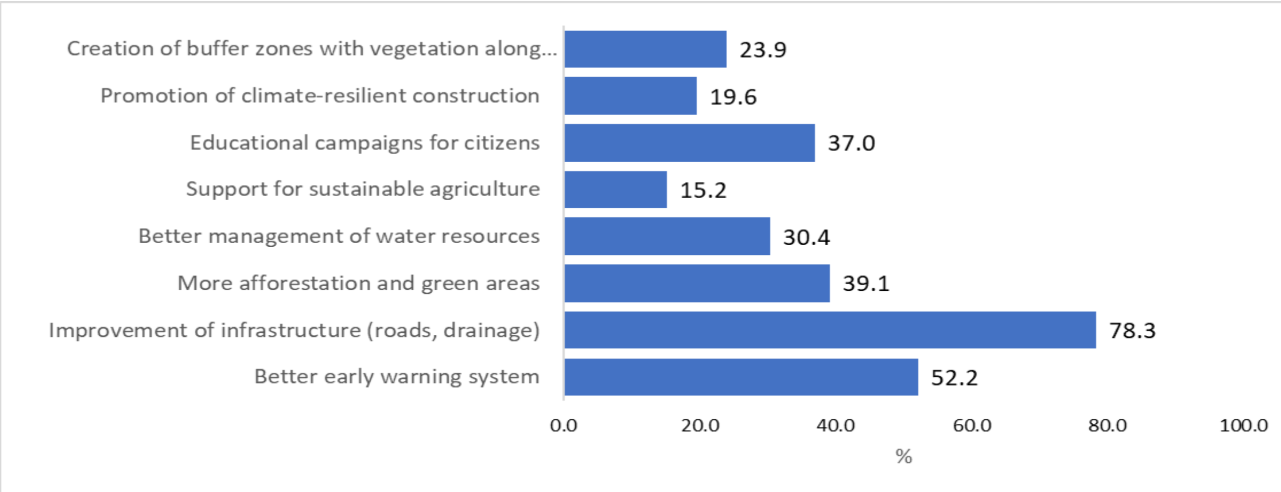


Figure 2.3 Answers to the questions: "What measures are necessary to reduce climate risk in your municipality?"

2.4.2 Gather output from Risk Analysis step

The risk evaluation for Dobrich-city Municipality builds on a comprehensive set of outputs generated during the Risk Analysis step, in accordance with the CLIMAAX Common Methodology Framework and the Key Risk Assessment Protocol. These outputs provide the analytical foundation for the assessment of risk severity, urgency, and local resilience capacity in the subsequent evaluation steps.

The Risk Analysis integrates results from the multi-hazard screening (Section 2.2), the regionalised risk assessment (Section 2.3), and the detailed technical analyses presented in Annex 1. Together, these outputs enable a consistent and transparent comparison of risks across hazards and support evidence-based prioritisation.

Hazard characterisation outputs

For each selected climate hazard—heatwaves, heavy rainfall and extreme precipitation, windstorms, river flooding, and snowfall and blizzards—the Risk Analysis produced quantitative and qualitative indicators describing hazard intensity, frequency, spatial extent, and projected future evolution.

Key hazard-specific outputs include:

- Heatwaves
  - Land Surface Temperature (LST)–based exposure maps derived from Copernicus datasets, identifying urban heat hotspots;
  - Observed maximum air temperature records confirming modelled exposure patterns;
  - Evidence of recurrent and prolonged heat stress in densely built urban areas.
- Extreme precipitation (3-hour and 24-hour events)
  - Modelled extreme precipitation statistics based on Generalised Extreme Value (GEV) distributions;
  - Return period analysis (typically 2–100 years) under future climate conditions (2041–2070);
  - Projected changes in rainfall intensity and return periods for critical thresholds (≥50 mm/24h).
- Windstorms and strong winds
  - Observed daily maximum wind gust data (NOAA, 2019–2023);
  - Frequency analysis of strong winds (>50 km/h) and windstorms (>70 km/h);
  - Identification of seasonal patterns and compound wind–precipitation events.
- River flooding
  - Historical flood occurrences, primarily linked to torrential rainfall;
  - Modelled flood extent and depth for selected return periods;
  - Identification of flood-prone urban zones and infrastructure stress points.

These hazard outputs enable comparison between current and future conditions and support assessment of climate change–related risk escalation, as recommended by the CLIMAAX Handbook.

Exposure assessment outputs

Exposure is assessed through spatial and sectoral indicators identifying who and what is located in hazard-prone areas, including:

- Population density and settlement pattern maps;
- Location of critical infrastructure, such as transport networks, drainage systems, public buildings, and utility assets;
- Concentration of economic activities, particularly in industry, services, and urban commercial zones;
- Urban areas with high impervious surface coverage and limited natural buffering capacity.

Exposure indicators are harmonised across hazards to ensure comparability and to support cross-risk evaluation.

Vulnerability assessment outputs

Vulnerability is evaluated using a combination of physical, social, and institutional indicators, reflecting both sensitivity and adaptive capacity. These include:

- Socio-demographic vulnerability, such as the presence of elderly populations, people with chronic illnesses, and low-income households;
- Structural vulnerability of buildings and infrastructure, including ageing drainage systems, overhead power lines, and transport assets;
- Institutional vulnerability, identified through stakeholder survey results, highlighting:
  - limited preparedness and response capacity;
  - insufficient awareness of evacuation plans;
  - gaps in early warning systems and risk communication.

These outputs are consistent with the CLIMAAX vulnerability concept and capture both direct impacts and systemic weaknesses.

Integrated risk outputs

For each analysed hazard, the Risk Analysis step generated integrated outputs combining hazard, exposure, and vulnerability, including:

- Hazard–Exposure–Vulnerability (H–E–V) scores, typically on a 1–3 scale;
- Risk matrices linking exposure and vulnerability under present and future climate conditions;
- Composite risk levels (e.g. moderate, high, critical), enabling prioritisation across hazards.

Indicative results include high to critical risk levels for heatwaves in central urban areas, critical risk levels for extreme precipitation due to increasing frequency and insufficient drainage capacity, and high risk levels for strong winds resulting from widespread exposure and recurrent damage.

Use of stakeholder perception data

Results from the structured stakeholder survey are used as supporting risk evidence, including information on perceived severity and frequency of hazards, sectoral impacts on health, infrastructure, and economic activities, and levels of awareness and preparedness. These perception-based outputs are not applied as standalone risk indicators but are used to contextualise and validate analytical findings, in line with the participatory principles of the CLIMAAX framework.

Role of outputs in risk evaluation

All outputs from the Risk Analysis step are systematically used to:

- compare risks across hazards on a consistent basis;
- assess risk severity by linking hazard intensity and exposure to potential impacts;
- assess risk urgency by considering observed trends, projected escalation, and institutional readiness;
- support transparent, evidence-based risk prioritisation.

By combining model-based results, local observations, and stakeholder input, the risk evaluation achieves both scientific robustness and policy relevance, as required by the CLIMAAX Key Risk Assessment process.

2.4.3 Assess Severity

In accordance with the CLIMAAX Key Risk Assessment Protocol, risk severity is defined as the potential magnitude of negative consequences associated with a climate hazard, assuming the event occurs. Severity is assessed independently of urgency and local response capacity and reflects the scale of potential impacts on people, infrastructure, economic activities, essential services, and the environment.

For Dobrich-city Municipality, severity has been assessed for both current and future climate risk, using a four-level qualitative scale:

- Limited – minor, localised impacts with negligible disruption;
- Moderate – noticeable impacts causing temporary disruption or manageable damage;
- Substantial – significant impacts affecting large population groups, key infrastructure, or economic sectors;
- Critical – very severe impacts with widespread damage, high human or economic loss, cascading effects, or potentially irreversible consequences.

The assessment draws on:

- historic and recent event evidence;
- outputs from the Risk Analysis (Sections 2.3 and Annex 1);
- projected changes under future climate conditions;
- stakeholder feedback collected through surveys and consultations (Section 2.4.1).

Table 2.2. Severity assessment by hazard (current and future risk)

Climate hazard	***Current severity***	***Future severity***	***Severity rationale***
Heatwaves	Substantial	Critical	Currently, heatwaves cause widespread health stress, increased morbidity, and pressure on health and social services, particularly affecting elderly people, children, and individuals with chronic illnesses. Impacts are city-wide and socially differentiated. In the future, increasing frequency, duration, and higher night-time temperatures significantly elevate the risk of excess mortality, cumulative health impacts, and cascading pressure on energy and healthcare systems, approaching critical severity.
Heavy rainfall / extreme precipitation	Substantial	Critical	Under current conditions, intense rainfall already causes flash flooding, damage to buildings and infrastructure, blocked roads, and disruption of services, with high financial losses in short timeframes. Future projections show increasing intensity and shortened return periods, raising the likelihood of widespread urban flooding, large economic damage, and cascading failures across transport, drainage, and emergency systems.

Climate hazard	Current severity	Future severity	Severity rationale
Windstorms / strong winds	Moderate–Substantial	Substantial	Currently, strong winds cause recurrent damage to roofs, trees, power lines, and transport infrastructure, leading to frequent service interruptions. While impacts are often localised, they affect large parts of the city. In the future, continued exposure and frequent compound events with rainfall increase the scale and persistence of damage, elevating severity to substantial.
River flooding	Moderate	Substantial	Present-day river flooding impacts are spatially limited and largely linked to extreme rainfall events rather than sustained river overflow. However, modelling shows that under future extreme scenarios, flood depths and affected areas could increase substantially, with significant damage to residential areas, industrial zones, and the need for evacuation, justifying a higher future severity rating.
Snowfall and blizzards	Moderate	Moderate	Snow and blizzard events currently cause short-term but potentially severe disruptions to transport, access to services, and energy supply. Impacts are generally temporary and manageable. Climate projections do not indicate a strong increase in severity, and while disruptive events will continue, severity is expected to remain moderate.

Key severity considerations

Scale and impact

The most severe climate risks for Dobrich-city Municipality are those capable of affecting large population groups and critical urban systems, notably heatwaves and extreme precipitation. These hazards already cause significant disruption and are projected to intensify, with potential for high human and economic losses.

Irreversibility and cascading effects

Heatwaves and extreme precipitation have the highest potential to generate cascading effects, such as health crises, power supply stress, transport disruption, and compounded emergency situations. Prolonged heatwaves, in particular, may lead to irreversible health outcomes, including excess mortality among vulnerable groups.

Stakeholder and expert perspectives

Stakeholder feedback enriches the severity assessment by highlighting perceived impacts on health, comfort, and professional activity. Floods and strong winds are often perceived as highly severe due to their visibility and disruptive nature, while heat-related risks tend to be underestimated despite their documented health impacts. This divergence underscores the importance of combining analytical evidence with stakeholder perspectives to achieve a balanced severity evaluation.

Survey results also indicate that while awareness of flood risk zones is high, understanding of response measures and evacuation procedures is more limited. This does not directly affect severity classification but reinforces the need to contextualise severity in relation to potential real-world consequences.

Decision-maker awareness

The assessment suggests that while municipal decision-makers have experience managing extreme events, further strengthening of climate risk literacy—particularly regarding heat-related and compound risks—would support more informed interpretation of severity and long-term implications.

Severity assessment summary

Overall, the severity assessment indicates that heatwaves and extreme precipitation represent the most severe climate risks for Dobrich-city Municipality, with substantial current impacts and critical future potential. Windstorms and river flooding show moderate to substantial severity, depending on event magnitude and future conditions, while snowfall and blizzards remain moderate in severity, characterised by episodic but manageable impacts.

2.4.4 Assess Urgency

In the CLIMAAX Key Risk Assessment framework, urgency reflects the time sensitivity of action required to address a climate risk. It considers how rapidly the risk is evolving, when major impacts are expected to occur, and whether delayed action would lead to disproportionate increases in damage or reduced effectiveness of response measures.

Urgency is assessed for both current and future risk, using the four categories defined in the Key Risk Assessment Protocol:

- No action needed – the risk is stable, with no significant impacts expected in the foreseeable future;
- Watching brief – the risk exists but evolves slowly or episodically; monitoring and preparedness are sufficient for now;
- More action needed – the risk is already affecting the community or is expected to worsen in the near future; additional measures are required;
- Immediate action needed – the risk is already severe or rapidly escalating; delayed action would significantly increase damage or losses.

The urgency assessment builds on the severity analysis (Section 2.4.3), projected climate trends, and stakeholder perceptions gathered through the engagement process (Section 2.4.1).

Table 2.3. Urgency assessment by hazard (current and future risk)

Climate hazard	***Urgency level***	***Urgency rationale***
Heatwaves	Immediate action needed	Heatwaves already occur regularly and affect health, comfort, and productivity. Severity increases markedly from current to future conditions, with higher frequency, longer duration, and increased night-time temperatures. Impacts are linked to both sudden

Climate hazard	Urgency level	Urgency rationale
		extreme events and slow-onset processes (urban heat island intensification), and the risk persists over time. Stakeholders report strong health impacts, particularly for vulnerable groups, indicating high time sensitivity.
Heavy rainfall / extreme precipitation	Immediate action needed	Extreme precipitation causes sudden, high-impact events such as flash flooding and infrastructure disruption. Severity increases significantly from current to future risk due to shorter return periods and higher rainfall intensity. Impacts are already occurring, and delayed action would rapidly increase damage. Stakeholders perceive floods and torrential rains as highly disruptive, reinforcing the need for immediate action.
Windstorms / strong winds	More action needed	Windstorms are recurrent and cause frequent damage and service disruption. While not all events are extreme, their frequency and frequent combination with heavy rainfall increase urgency. Impacts are associated with sudden events rather than slow-onset processes. Stakeholders identify strong winds as a frequent and tangible risk, suggesting that additional preventive and preparedness measures are needed in the near term.
River flooding	Watching brief	River flooding impacts are less frequent and largely associated with extreme rainfall events rather than persistent river overflow. While future severity may increase under extreme scenarios, major impacts are not expected to occur regularly in the near term if maintenance and preparedness are sustained. Monitoring, maintenance, and preparedness are therefore appropriate at this stage.
Snowfall and blizzards	Watching brief	Snow and blizzard events are episodic and do not show a clear trend of worsening severity. Impacts are linked to sudden events but are generally short-lived and manageable through existing response systems. Continued monitoring and preparedness are sufficient, without the need for immediate structural intervention.

Key urgency considerations

- ***Change from current to future risk***

Heatwaves and extreme precipitation show the most pronounced increase in severity from current to future conditions, justifying the highest urgency classification. Other hazards show more stable or conditional changes.

- ***Timing and persistence of impacts***

Heatwaves represent a persistent and cumulative risk, while heavy rainfall and windstorms are sudden-onset hazards with immediate disruptive effects. Both types increase urgency, but for different reasons.

- ***Stakeholder and vulnerable group perspectives***

Stakeholder feedback highlights strong concern about floods, strong winds, and health impacts, reinforcing urgency for hazards that directly affect daily life and economic activity. Heat-related risks are perceived as highly impactful on health and comfort, even if sometimes underestimated in economic terms.

- ***Decision-making implications***

Urgency scoring reflects not only projected climate change but also the window of opportunity for action. For heatwaves and extreme precipitation, delayed action would significantly reduce the effectiveness of future adaptation efforts.

Urgency assessment summary

The urgency assessment identifies heatwaves and heavy rainfall / extreme precipitation as climate risks for which immediate action is needed, due to escalating impacts, strong future change signals, and high sensitivity to delayed intervention. Windstorms require more action, while river flooding and snowfall/blizzards warrant a watching brief, focused on monitoring, maintenance, and preparedness.

2.4.5 Understand Resilience Capacity

In accordance with the CLIMAAX Key Risk Assessment Protocol, resilience capacity describes the extent to which Dobrich-city Municipality currently possesses the financial, institutional, social, human, physical, and natural resources required to manage, respond to, and recover from climate-related risks. The assessment focuses on existing and already implemented measures, while also considering formally planned interventions where relevant.

Resilience capacity is assessed using a four-level qualitative scale:

- Low – limited or fragmented capacity, with major gaps;
- Medium – basic capacity exists, but important weaknesses remain;
- Substantial – well-established capacity with functioning systems and coordination;
- High – strong, proactive, and adaptive capacity capable of managing severe events.

The assessment is informed by municipal documentation, stakeholder engagement (Section 2.4.1), observed response performance during past events, and the analytical outputs of the Risk Analysis.

Table 2.4. Existing climate risk management capacity by hazard

Climate hazard	*Resilience capacity*	*Capacity rationale (existing measures and gaps)*
Heatwaves	Medium	Basic capacity exists through the healthcare system, emergency medical services, and social support mechanisms. Public health institutions respond to heat-related incidents, and municipal services provide assistance to vulnerable groups. However, there are limited heat-specific action plans, insufficient urban green and blue infrastructure, uneven access to cooling, and no systematic early warning and outreach system tailored to heat risk. Human and social capacity exists but is not yet fully operationalised for extreme heat.

Climate hazard	Resilience capacity	Capacity rationale (existing measures and gaps)
Heavy rainfall / extreme precipitation	Low–Medium	Existing capacity includes stormwater drainage systems, emergency response services, and ad hoc maintenance activities. However, physical capacity is constrained by ageing and undersized drainage infrastructure, high impervious surface coverage, and limited natural retention areas. Financial and natural capacity to absorb increasing rainfall intensity is limited. While emergency response exists, preventive and adaptive capacity remains insufficient for escalating risks.
Windstorms / strong winds	Medium	Emergency services, municipal maintenance units, and utility operators have experience responding to wind-related incidents such as fallen trees, damaged roofs, and power outages. Physical response capacity is generally adequate for frequent events. However, preventive measures (e.g. reinforcement of infrastructure, vegetation management, reduction of overhead utilities) are limited, constraining resilience under compound wind–rain events.
River flooding	Substantial	The regulated river channel, existing flood protection structures, flood risk awareness, and established emergency procedures provide a relatively strong baseline capacity. Flood hazard mapping and emergency response protocols are in place, and river flooding is a well-recognised risk. Capacity remains substantial under most conditions, although it depends on regular maintenance and may be challenged during extreme, low-probability events.
Snowfall and blizzards	Substantial	Operational preparedness for winter conditions is well developed, including snow removal services, road maintenance, emergency response, and coordination with utility providers. Human, physical, and institutional capacity for winter risk management is relatively strong, and response systems are adapted to episodic winter extremes.

Cross-cutting capacity dimensions

Across all hazards, resilience capacity in Dobrich-city Municipality is shaped by the following dimensions:

Financial capacity

Municipal budgets allow for emergency response and routine maintenance but are limited in supporting large-scale preventive or adaptive investments without external funding.

Human and institutional capacity

Emergency services and municipal departments have operational experience in disaster response. However, stakeholder feedback indicates gaps in climate-specific risk understanding, particularly for heatwaves and compound risks, suggesting a need for strengthened training and learning.

Physical capacity

Forecasting and warning systems exist at national level and are accessible locally, but local-level integration, especially for short-duration rainfall and heat stress, is limited. Ageing infrastructure represents a key weak spot.

Natural capacity

The municipality has limited natural buffering capacity due to extensive sealed surfaces and insufficient green-blue infrastructure, reducing the ability to absorb heat and heavy rainfall.

Social capacity

Public awareness of certain risks, particularly flooding, is relatively high, but preparedness and knowledge of response actions (e.g. evacuation plans) remain uneven. Social inclusion mechanisms exist but are not fully leveraged for climate risk reduction.

Implemented and planned interventions

Dobrich-city Municipality has implemented several foundational risk management measures, including emergency response systems, flood protection structures, winter maintenance services, and sectoral plans aligned with national disaster risk management frameworks. At the same time, the assessment indicates that many interventions relevant to climate adaptation are planned or under consideration rather than fully implemented, particularly in relation to urban drainage upgrades, green infrastructure, and heat risk management.

Resilience capacity assessment summary

Overall, resilience capacity in Dobrich-city Municipality ranges from low–medium for heavy rainfall, medium for heatwaves and windstorms, and substantial for river flooding and snowfall/blizzards. Existing systems provide a functional baseline for managing episodic events, but capacity is increasingly strained by escalating and systemic risks, particularly those related to extreme precipitation and heat.

This uneven capacity profile plays a decisive role in the final risk prioritisation, as risks combining high severity and urgency with low or medium resilience capacity require the highest level of attention in adaptation planning.

2.4.6 Decide on Risk Priority

The final risk prioritisation for Dobrich-city Municipality was carried out using the CLIMAAX Key Risk Assessment Evaluation Dashboard, which integrates the three evaluation dimensions—severity, urgency, and resilience capacity—into a single, transparent decision-support framework. This step builds directly on the assessments presented in Sections 2.4.3, 2.4.4, and 2.4.5 and follows the guidance provided in the Key Risk Assessment Protocol.

The dashboard was used as a facilitated evaluation tool, supporting structured discussion with stakeholders, experts, and municipal representatives. For each climate hazard, the agreed severity (current and future), urgency of action, and existing resilience capacity were entered into the dashboard. The resulting risk priority level reflects the combined interpretation of:

- the potential magnitude of impacts;
- the time sensitivity of action;
- the ability of existing systems and measures to manage the risk.

Risk priority levels are expressed using a qualitative four-step logic, consistent with the Evaluation Dashboard:

- Low priority
- Medium priority
- High priority
- Very high priority

Risk priority results

Table 2.5a. Risk Assessment Evaluation Dashboard

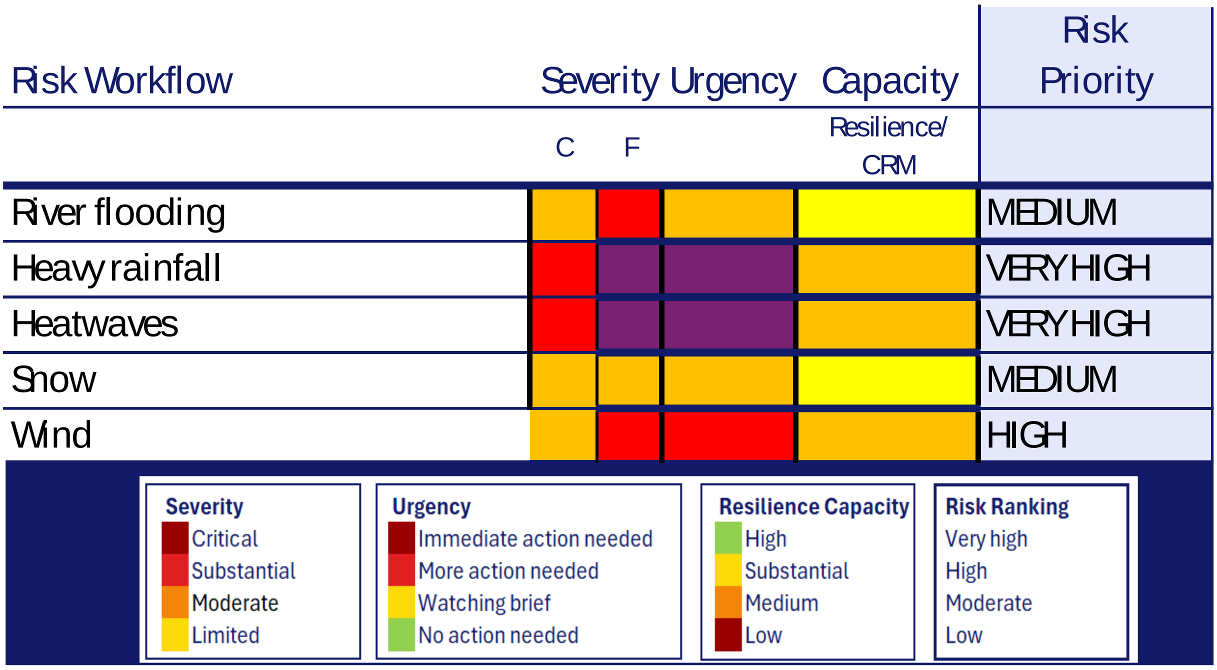


Table 2.5b. Risk Assessment Evaluation Dashboard explained

Climate hazard	***Severity (current / future)***	***Urgency***	***Resilience capacity***	***Risk priority***	***Interpretation***
Heatwaves	Substantial / Critical	Immediate action needed	Medium	**Very high priority**	Heatwaves combine escalating severity, persistent and cumulative impacts, and only medium existing capacity. Delayed action would significantly increase health risks and strain essential services.

Climate hazard	Severity (current / future)	Urgency	Resilience capacity	Risk priority	Interpretation
Heavy rainfall / extreme precipitation	Substantial / Critical	Immediate action needed	Low–Medium	**Very high priority**	Extreme precipitation already causes sudden, high-impact events and is expected to worsen in the near future. Limited physical and natural capacity makes this risk highly sensitive to delayed intervention.
Windstorms / strong winds	Moderate–Substantial / Substantial	More action needed	Medium	**High priority**	Windstorms are frequent and disruptive, particularly when combined with rainfall. Existing response capacity exists, but preventive and adaptive measures are insufficient to fully manage recurring impacts.
River flooding	Moderate / Substantial	Watching brief	Substantial	**Medium priority**	River flooding can cause severe impacts under extreme scenarios but is less frequent and more spatially limited. Existing flood management capacity reduces overall priority, provided maintenance and monitoring are sustained.
Snowfall and blizzards	Moderate / Moderate	Watching brief	Substantial	**Medium priority**	Winter extremes are episodic and generally well managed through existing operational systems. Continued preparedness is required, but immediate large-scale action is not warranted.

Interpretation of prioritisation results

The dashboard-based prioritisation clearly identifies heatwaves and heavy rainfall / extreme precipitation as the highest priority climate risks for Dobrich-city Municipality. These hazards combine:

- substantial to critical severity, particularly under future climate conditions;
- immediate urgency, due to already occurring impacts and near-term escalation;
- limited or only medium resilience capacity, increasing sensitivity to delayed action.

Windstorms represent a high priority risk, driven by frequent disruption and compound effects with precipitation, but moderated by existing response capacity.

River flooding and snowfall/blizzards are assigned medium priority, reflecting their episodic nature, more limited spatial extent, and relatively stronger existing management capacity. These risks require continued monitoring, maintenance, and preparedness rather than immediate structural intervention.

Role of the dashboard in decision-making

The Evaluation Dashboard enabled a transparent and participatory prioritisation process, ensuring that:

- analytical evidence from the Risk Analysis was clearly reflected;
- stakeholder perceptions were considered and discussed;
- differences between current and future risk were explicitly acknowledged;
- priority setting was traceable and reproducible.

2.5. Monitoring and Evaluation

The second phase of the climate risk assessment provided Dobrich-city Municipality with a more robust, evidence-based and locally contextualised understanding of its key climate risks, building on and refining the results of Phase 1. The learning process followed the CLIMAAX Common Methodology Framework and demonstrated the value of combining scientific analysis, local knowledge, and stakeholder engagement in climate risk assessment.

Key lessons learned and challenges encountered

A central lesson from Phase 2 was the importance of high-level scientific input for credible and policy-relevant climate risk assessment. The involvement of Prof. Hristova (Climate, Atmosphere and Water Research Institute, Bulgarian Academy of Sciences) proved indispensable for ensuring scientific robustness, particularly in hazard modelling and interpretation of results. Her participation also increased the visibility and legitimacy of the project among municipal decision-makers and stakeholders.

At the same time, the project revealed clear limitations in local institutional capacity, particularly in relation to advanced data analysis and modelling. This confirmed the need for external technical support, which was successfully provided by D&D Consulting.

The most significant difficulties encountered during Phase 2 were related to data availability and data integration. High-resolution, locally calibrated climate and hydrological data were limited, and data ownership was fragmented across institutions. Translating technically complex CRA outputs into accessible and understandable information for stakeholders also proved challenging, especially given time and resource constraints. These challenges required iterative consultation with municipal experts and the complementary use of expert judgement, in line with the CLIMAAX Handbook.

Role of stakeholders in monitoring and evaluation

Stakeholder involvement has been a cornerstone and guiding principle of the ARCADIA project. During Phase 2, stakeholders played a key role not only in validating risk assessment results, but also in shaping learning and monitoring processes.

Feedback from different stakeholder groups highlighted concrete needs and priorities:

- the municipal administration emphasised infrastructure vulnerability, particularly the urgent need for investment in drainage systems;
- fire and emergency services pointed out inaccuracies in floodplain mapping and the need for more precise and operationally relevant risk assessments;
- hydrology and urban planning experts recommended measures such as riverbed maintenance and widening, buffer zones along riverbanks, and integrated flood mitigation strategies;
- community representatives demonstrated mixed levels of awareness, underlining the need for targeted education and clearer communication.

Looking ahead to Phase 3, stakeholders will be instrumental in monitoring the integration of CRA results into local policy documents, including the revision of the municipal disaster risk reduction programme, thereby strengthening ownership, legitimacy, and long-term impact.

Learning processes and continuity

Learning has been ensured through an iterative and participatory approach, combining:

- continuous interaction between project partners and municipal experts;
- structured stakeholder engagement through surveys and workshops;
- validation and refinement of results based on feedback.

Further learning and monitoring will be supported through:

- participation in project events, including the workshop planned for 28 January 2026 and the final conference;
- involvement in discussions on the revision of municipal strategic documents;
- communication and outreach activities, including social media, press releases, and public events.

Data availability and future needs

Phase 2 revealed a mixed picture regarding data availability. While some meteorological data are available (e.g. NOAA Dobrich Weather Observation Reports for 2019–2023), there are no long-term local time series for strong winds (especially short-duration gusts), torrential rainfall, or heatwaves. Hydrological data are particularly limited, as the Dobrichka River gauging station operated only briefly in the past.

The assessment identified the need for:

- high-resolution rainfall and runoff data for the Dobrichka River and its tributaries;
- detailed information on the condition and capacity of urban drainage systems;
- enhanced modelling capacity and targeted training for integrating climate risk assessment into spatial and urban planning.

Communication of results

Communication of the project's outcomes will follow the approved communication plan, aiming to reach at least 5,000 residents, as well as key local and regional authorities and stakeholders, through local and national media and social media channels. Based on the experience from Phase 2 and feedback from the second workshop, Phase 3 will place stronger emphasis on practical outreach and applicability, particularly through public participation in the review and revision of municipal planning documents.

Monitoring systems and institutional embedding

Dobrich-city Municipality does not currently operate a single, unified climate risk monitoring system (such as a real-time digital dashboard). However, climate risks are addressed through several existing planning and reporting instruments, including:

- the Integrated Development Plan 2021–2027, which assesses temperature and precipitation trends;
- the Municipal Disaster Risk Reduction Programme 2021–2025, which covers flood risk, fires, and adverse weather events.

Based on the ARCADIA project results and the CLIMAAX CRA framework, the municipality could introduce a periodic (5–10 year) climate risk monitoring cycle for key hazards such as flooding, heavy rainfall, and heatwaves, complemented by systematic documentation of major climate-related events.

What worked well and what did not

What worked well

- application of the CLIMAAX risk prioritisation protocol;
- increased awareness among stakeholders of the value of CRA for adaptation planning;
- effective integration of stakeholder perspectives;
- strong commitment from the municipal administration;
- good cooperation between municipal experts and external technical specialists.

What worked less well

- limited data interoperability;
- insufficient time for broader stakeholder engagement;
- limited involvement of regional and national-level stakeholders.

Efficiency and overall impact

Overall, the project used available resources efficiently in terms of time, staff effort, and cost. The main negative factor was the lengthy public procurement process for external expertise, which caused delays but was ultimately completed in time to ensure high-quality inputs.

The CRA process has had a clear positive impact on:

- institutional understanding of climate risks;
- stakeholder awareness and engagement;
- readiness to apply science-based evidence in local planning.

This impact is already visible in follow-up fundraising efforts, including a successful application under the Pathways2Resilience project to develop a climate resilience strategy, action plan, and investment plan.

The ARCADIA CRA has contributed to a shift in perception of climate change from an abstract global issue to a concrete local challenge affecting daily life, public services, and economic activity. Institutional capacity has been strengthened among directly involved experts, and Phase 3 is expected to further embed CRA results through policy and normative changes, supported by continued fundraising and investment efforts.

2.6. Work plan Phase 3

The final phase of the project will focus on translating the key climate risk assessment findings into actionable and locally relevant adaptation pathways for Dobrich-city Municipality. Building on the prioritised risks identified in Phase 2 through the Key Risk Assessment, Phase 3 will aim to identify, assess, and structure feasible adaptation policies and measures that can reduce future climate impacts and strengthen municipal resilience.

Main activities of Phase 3

- ***Follow-up on priority risks***

Phase 3 will focus exclusively on the priority climate risks identified through the Evaluation Dashboard, based on their assessed severity, urgency, and resilience capacity. The results from Phases 1 and 2 will be consolidated to define clear adaptation objectives that respond to the most pressing and decision-relevant risks for Dobrich-city Municipality.

- ***Identification of adaptation measures***

Potential adaptation options will be identified for each priority risk, drawing on the CLIMAAX Toolbox, relevant European best practices, and local knowledge. The measures considered will include structural, non-structural, nature-based, and governance-related interventions, ensuring a balanced and integrated approach to climate adaptation.

- ***Assessment of adaptation options***

Identified measures will be qualitatively assessed in terms of effectiveness, feasibility, implementation timeframe, co-benefits, and potential trade-offs. The assessment will explicitly consider local financial, institutional, spatial, and social constraints, with the objective of ensuring that proposed measures are realistic, implementable, and aligned with municipal capacities.

- ***Stakeholder-informed refinement***

Stakeholders, experts, and priority groups will be actively engaged during Phase 3, particularly in the review and revision of the municipal disaster risk reduction programme and, where relevant, other municipal strategic documents. Stakeholders will also be involved through the final conference, which will serve to present project results and disseminate key findings and recommendations. These participatory steps will support ownership, legitimacy, and policy relevance of the outcomes.

- ***Integration into planning and decision-making***

The final set of adaptation options will be structured to facilitate their integration into municipal strategies, sectoral plans, and future investment decisions, thereby ensuring continuity between risk assessment, policy development, and implementation.

Scope and limitations

Phase 3 will not revisit the detailed hazard modelling or regionalised risk analysis undertaken in Phases 1 and 2, nor will it address climate risks that were not identified as priorities through the Key Risk Assessment. This focused scope ensures efficient use of resources and allows the project to concentrate on implementable adaptation actions for the most significant risks.

Continuity with the Key Risk Assessment

Phase 3 directly follows up on the outcomes of the Key Risk Assessment by:

- addressing only the risks identified as priorities in Phase 2;
- aligning adaptation options with the assessed severity, urgency, and resilience capacity;
- ensuring that proposed measures target identified weaknesses in financial, institutional, physical, natural, and social capacity.

This approach guarantees continuity between assessment and action, enabling Dobrich-city Municipality to move from risk understanding to evidence-based and implementable climate adaptation planning, in line with the CLIMAAX Framework.

3 Conclusions Phase 2- Climate risk assessment

Phase 2 of the CLIMAAX-supported climate risk assessment for Dobrich-city Municipality successfully extended, refined, and prioritised the climate risks initially identified in Phase 1, providing a robust analytical and participatory basis for decision-making and subsequent adaptation planning.

Main conclusions and challenges addressed

A key conclusion of Phase 2 is that climate risks in Dobrich-city Municipality are already materialising and are expected to intensify, particularly those related to heatwaves and heavy rainfall. The application of the CLIMAAX Common Methodology Framework and the Key Risk Assessment Protocol enabled a structured transition from hazard identification to evidence-based risk prioritisation, integrating scientific analysis with stakeholder knowledge.

Phase 2 effectively addressed several critical challenges:

- it moved the assessment from a single-hazard perspective to a multi-hazard approach, reflecting the complex and interacting nature of climate risks at municipal level;
- it improved the local relevance and credibility of the assessment through high-level scientific input and the integration of local data and expert judgement;
- it strengthened institutional learning and stakeholder awareness, demonstrating the practical value of climate risk assessment as a planning and policy tool.

At the same time, some challenges could not be fully addressed within the scope of Phase 2. These include limited availability of high-resolution local climate and hydrological data, constraints on the depth of stakeholder engagement due to time and resource limitations, and the absence of a unified local climate risk monitoring system. These limitations were explicitly documented and informed the design of Phase 3 activities.

Key findings of the Phase 2 risk assessment

The key findings of Phase 2 can be summarised as follows:

- Heatwaves and heavy rainfall / extreme precipitation were identified as the highest priority climate risks for Dobrich-city Municipality. Both hazards combine substantial to critical severity, immediate urgency, and only low to medium resilience capacity, indicating a strong need for near-term adaptation action.
- Windstorms represent a high-priority risk, characterised by frequent occurrence, widespread exposure, and strong interactions with other hazards, particularly heavy rainfall.
- River flooding and snowfall and blizzards remain relevant but were assessed as medium-priority risks, reflecting their more episodic nature, spatially limited impacts, and relatively stronger existing management capacity.
- The assessment highlighted the importance of compound and cascading risks, especially the interaction between heavy rainfall, windstorms, and urban infrastructure vulnerabilities.
- Stakeholder engagement confirmed the practical relevance of the analytical findings, while also revealing gaps between risk awareness and preparedness, particularly regarding response measures and evacuation procedures.
- The evaluation of resilience capacity demonstrated an uneven ability to cope with climate risks, with systemic and escalating hazards (heatwaves and extreme precipitation) posing the greatest challenge to existing institutional, infrastructural, and social capacities.

Overall assessment

Overall, Phase 2 achieved its objective of delivering a clear, prioritised, and decision-relevant climate risk assessment for Dobrich-city Municipality. The combination of scientific evidence, local expertise, and stakeholder input resulted in a shared understanding of climate risks as concrete local challenges, rather than abstract or distant threats.

The outcomes of Phase 2 provide a solid and defensible foundation for Phase 3 adaptation planning, ensuring continuity between risk assessment and action. By explicitly identifying priority risks, key vulnerabilities, and capacity gaps, the assessment enables Dobrich-city Municipality to move forward with targeted, feasible, and evidence-based climate adaptation measures in line with the CLIMAAX Framework.

4 Progress evaluation

This deliverable consolidates the analytical results achieved in the Phase 2 of the project and serves as a direct input for the subsequent phase 2 of the ARCADIA project for Dobrich-city municipality. The CRA outputs provide a structured and validated climate risk evidence base, ensuring continuity between climate risk assessment and local adaptation planning. The climate risks that have been identified and prioritized, together with the improved assessment of exposure and vulnerability, will be the basis for the policy-building phase, which focuses on discussion and decision-making of climate adaptation policies and measures. The identification of key risk hazards and drivers will assist the project team and municipal administration in the review and revision of the municipal disaster risk reduction program and other municipal strategic documents.

In addition, the clear methodological framework of CLIMAAX, the process of data collection and analysis and the involvement of the key stakeholders will enable a focused and inclusive process of completing the project with important policy deliverables and enhanced public awareness. The next final phase of the project will showcase a process of municipal climate resilience planning. The lessons learnt could have spillover effects on other municipal processes that apply scientific knowledge in policy-making.

Table 4.1 Overview key performance indicators

Key performance indicators	*Progress*
1 climate multi-risk assessment report published	Submitted
5000 residents, key local and regional authorities, and stakeholders reached through local and national media, incl. social media channels. (accumulative, by the end of the project)	To date, more than 100 individuals, key local and regional authorities and stakeholders have attended the project's events as well as more than 1300 others reached out through local and national media and social media channels.
At least 5 local or national NGOs and 20 local community members involved in the workshops with stakeholders and in the final conference (accumulative, by the end of the project)	In the process of implementation.
Second workshop with stakeholders - local, regional and national stakeholders to gather additional data and insights	It will be organized on 28.01.2026. Initial feedback will be collected with the registration forms. Agenda, invitations sent, presentations prepared. https://www.dobrich.bg/bg/novini/obshtina-grad-dobrich-kani-zainteresovani-strani-na-seminar-za-obsazhdane-na-klimatichnite-riskove-i-adaptatsionni-merki

Table 4.2 Overview milestones

Milestones	*Progress*
Attend the CLIMAAX workshop held in Barcelona	Workshop attended and poster presented.
Completion of the desktop research on municipal, regional, and national data related to climate risks and vulnerable sectors	Competed
Submission and acceptance of the report on multi-risk assessment results	Submitted
Workshop with local, regional and national stakeholders to gather additional data and insights	It will be organized on 28.01.2026. Initial feedback will be collected with the registration forms. Agenda, invitations sent, presentations prepared. https://www.dobrich.bg/bg/novini/obshtina-grad-dobrich-kani-zainteresovani-strani-na-seminar-za-obsazhdane-na-klimatichnite-riskove-i-adaptatsionni-merki

5 Supporting documentation

- *Main Report (PDF)*
- *Visual Outputs (infographics, maps, charts)*

Annex 1 – Regionalized Risk Analysis
Annex 2 – Archive with CLIMAAX Jupyter Notebooks

- *Communication Outputs (Press release, media)*

https://www.dobrich.bg/bg/novini/obshtina-grad-dobrich-kani-zainteresovani-strani-na-seminar-za-obsazhdane-na-klimatichnite-riskove-i-adaptatsionni-merki

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