CLIMAAX
climate ready regions

Deliverable Phase 1 – Climate risk assessment

"Towards Climate Resilience: Assessing Silistra's Climate Challenges and Solutions"

(TOR: Towards Climate Resilience)

Bulgaria, Silistra

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

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• Document Information

Deliverable Title	Phase 1 – Climate risk assessment
Brief Description	The climate risk assessment report has as a main objective the application of the CLIMAAX methodology to conduct a multi-risk assessment, focusing on key climate hazards and vulnerabilities relevant for Silistra municipality. The project team has compiled a comprehensive report that details the methodology's application adapted to the local context, and taking into account the stakeholder feedback.
Project name	"Towards Climate Resilience: Assessing Silistra's Climate Challenges and Solutions" (TOR: Towards Climate Resilience)
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1.0	...	Silistra Municipality	Deliverable submitted
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5.0	...		Final version to be submitted

• Table of contents

List of figures

- ## List of tables

Abbreviations and acronyms

Abbreviation / acronym	Description
BGN	Bulgarian Leva
CLIMAAX	CLIMAte risk and vulnerability Assessment framework and toolbox project
CRA	Climate Risk Assessment
EEA	European Environmental Agency
EU	European Union
IFP	Individual Follow-up Plan
IME	Institute for Market Economics
MIDP	Municipal Integrated Development Plan
RCP	Representative Concentration Pathway
SPA	Spatial Planning Act

Executive summary

Motivation

This deliverable documents the initial phase of the project "Towards Climate Resilience: Assessing Silistra's Climate Challenges and Solutions." Its primary purpose is to apply and test the CLIMAAX methodology and toolbox within the specific context of Silistra Municipality, focusing on initiating a multi-risk climate assessment. This report addresses the need for a structured, harmonized approach to understanding climate risks locally. Readers will learn about the adaptation of the CLIMAAX framework to Silistra, the process undertaken, and the preliminary findings for the selected pilot hazards.

Main Results and Findings

During this phase, the main action undertaken has been the initial application of the CLIMAAX methodology to begin the climate risk assessment process for Silistra. Based on the need to first test the methodology and toolbox provided by CLIMAAX, the analysis concentrated specifically on two key climate hazards identified as highly relevant for the municipality: River Floods and Heavy Rainfall.

The core activities involved adapting the standardized CLIMAAX framework to incorporate local data and conditions relevant to these specific hazards. Stakeholder feedback was considered during this adaptation process. The application involved utilizing the CLIMAAX toolbox workflows for hazard assessment, exposure analysis, and vulnerability assessment pertinent to river floods and heavy rainfall.

The main result achieved is the successful validation of the CLIMAAX methodology's applicability for Silistra concerning the analyzed hazards. Preliminary risk assessments for river floods and heavy rainfall have been produced, providing initial insights into potential impacts and vulnerable areas related to these specific threats. This deliverable establishes a foundational understanding and a tested approach for these hazards.

This phase contributes significantly to the project‘s objectives by confirming the suitability of the chosen methodology for the local context and providing the essential groundwork and validated workflows. These initial results serve as a crucial input and pilot study for the subsequent, more comprehensive multi-risk assessment planned for the municipality, which will cover a broader range of climate hazards.

Conclusions

The key take-away messages from this initial phase are:

- ✓ The CLIMAAX methodology and toolbox were successfully applied and validated for assessing specific climate hazards (River Floods and Heavy Rainfall) in Silistra.
- ✓ Preliminary risk insights for these two hazards have been generated, providing an initial understanding of their potential impact.
- ✓ This work forms a critical foundation for the subsequent project phases, which will expand the assessment to encompass the full spectrum of relevant climate risks facing Silistra Municipality.

1 Introduction

1.1 Background

Silistra Municipality – General Characteristics

The Municipality of Silistra is located in the northeastern part of Bulgaria, in the Silistra District, and covers an area of about 516 sq. km. The city of Silistra, which is the administrative center, is the main settlement, and the municipality includes 19 other settlements. Geographically, the municipality borders the Danube River to the north, which places it in a strategically important location for cross-border cooperation and access to international transport corridors.

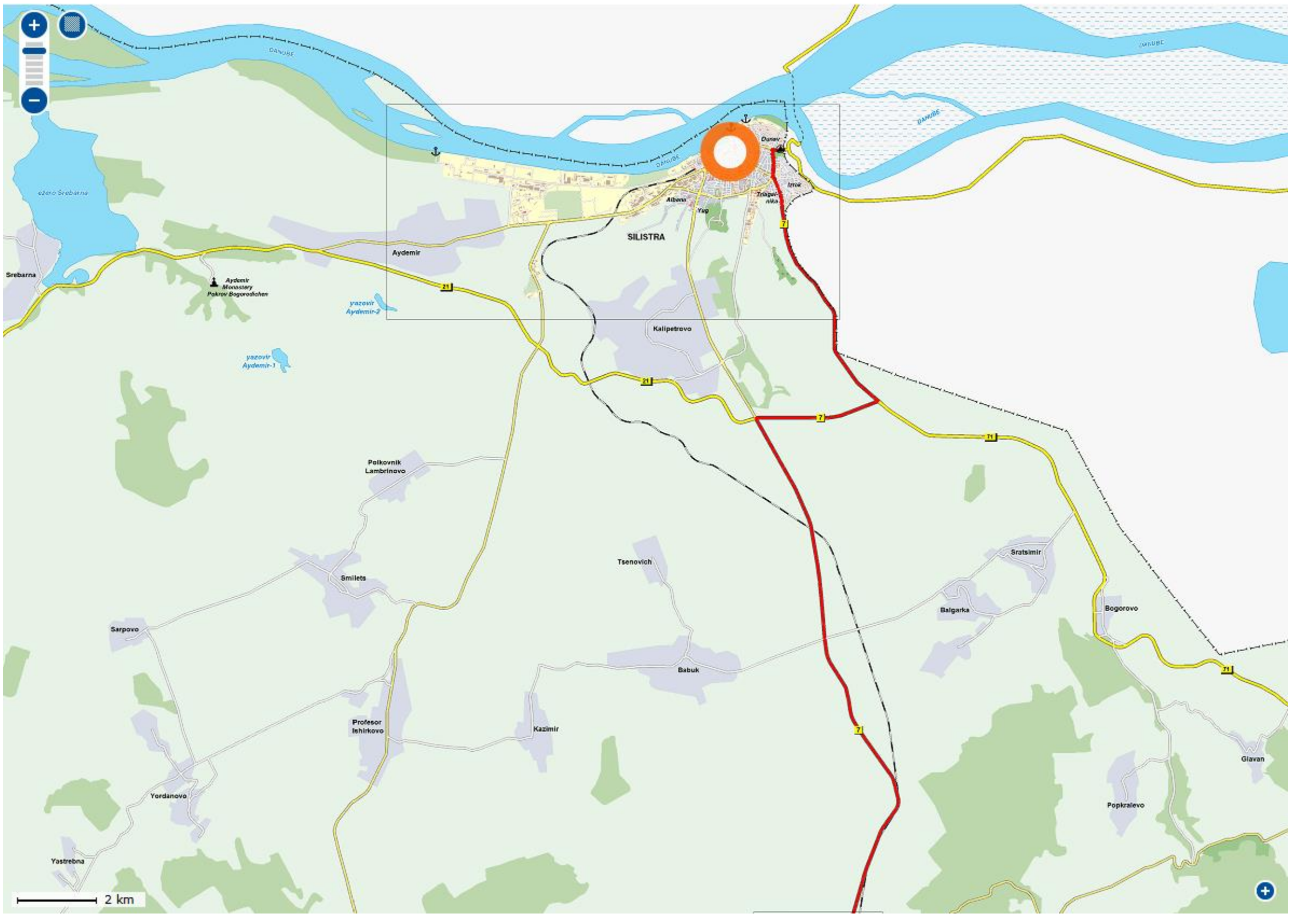

Figure 1 – Map of Silistra Municipality

Relief

The relief of the Silistra municipality is mainly flat-hilly, typical of the Dobrudzha Plateau, with gently sloping terrain towards the Danube River to the north.

In the northern part of the municipality, along the Danube, lowlands and river terraces, formed by alluvial soils, predominate, making the area suitable for agriculture. Here are alluvial plains and floodplain terraces, which are the result of the long-term activity of the river.

In the southern part of the municipality, the terrain becomes more hilly and transitions into the plateau relief typical of Dobrudzha. The heights vary between 50 and 150 meters above sea level, with the highest points being in the southern regions.

Loess deposits predominate, forming fertile soils, but also creating conditions for landslides and erosion processes, especially in areas with intensive agriculture.

In general, the relief of the Silistra municipality is favorable for agriculture and transport infrastructure, but requires appropriate measures to prevent erosion and landslides in some areas.

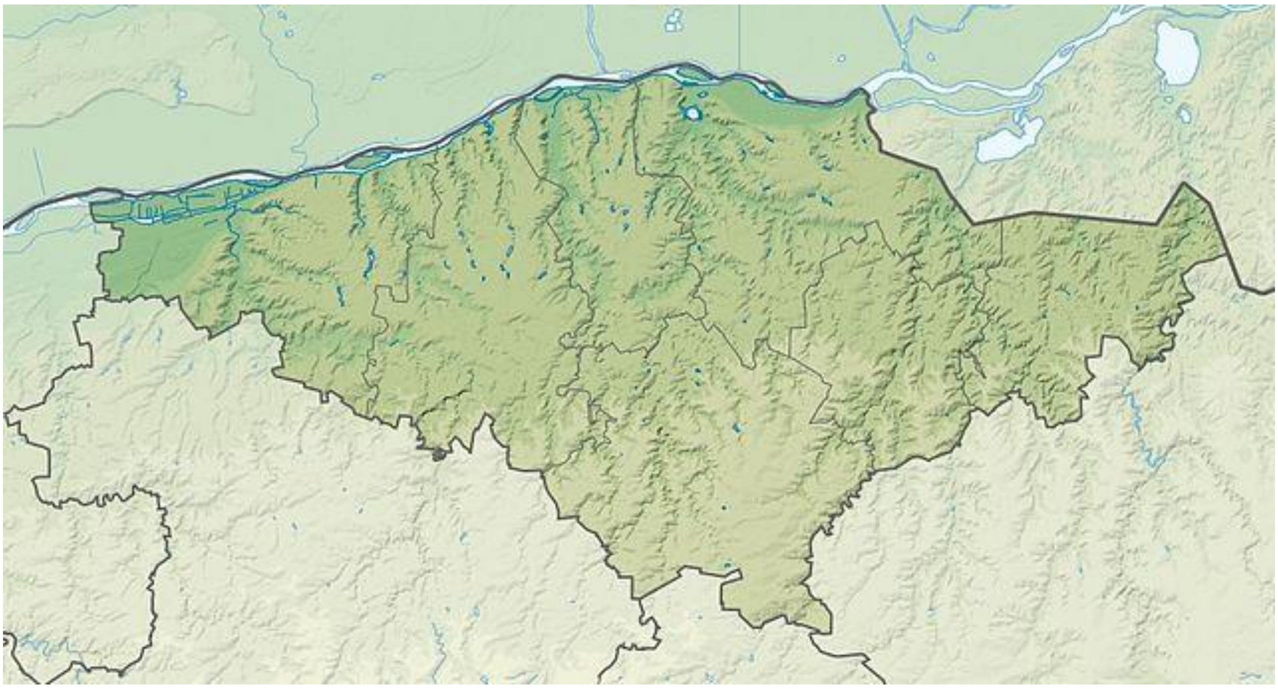

Figure 2 - Physical map of Silistra Municipality

Climatic factors

Silistra Municipality falls into the temperate continental climate zone of the European continental climate zone. Main climatic parameters:

- ✓ Average annual temperature: About 11-12°C
- ✓ Summer temperatures: Often reach 35-40°C
- ✓ Winter temperatures: Drop to -15°C, sometimes lower
- ✓ Average annual rainfall: 500-600 mm
- ✓ Snowfall: Mainly in December-February, but with the warming of the climate, snow becomes less frequent.

The territory of the Silistra municipality falls into the temperate continental climate subregion of the European continental climate region. The average annual air temperature is 10.2°C. The absolute temperature minimum is recorded in January - minus 22.7°C, and the maximum - in August and September - plus 39.1°C. The region is characterized as windy (north-northwest winds) with high air humidity and low precipitation - 540 mm on average annually, with a well-developed continental regime. The summer maximum is in June, the winter minimum - in February. 80% of the annual precipitation falls in summer.

The average relative humidity is 78%. During the winter period, the humidity reaches 85-86%, and in the summer it drops to 68-69%.

Climate change and vulnerability of Silistra Municipality.

Silistra Municipality, as part of the Northeastern Bulgaria region, is vulnerable to climate change, which includes increasing temperatures and intense precipitation, as well as the frequency of associated extreme events such as droughts and floods. These events can have serious consequences for the economy and health of the population in the region.

The Municipality of Silistra is committed to participating in the implementation of national strategies for adaptation to climate change. This includes:

- ✓ Integrating adaptation into local policies: Municipalities should integrate adaptation measures into their local policies and development plans, focusing on sectors such as water supply, energy and transport.
- ✓ Strengthening infrastructure: Municipalities should work to strengthen infrastructure, focusing on water supply and energy infrastructure, to increase resilience to climate change.
- ✓ Raising awareness: Municipalities should work to raise awareness among the population about the risks and adaptation measures to climate change.

The Municipality of Silistra is committed to participating in the implementation of the National Strategy for Adaptation to Climate Change by integrating adaptation measures into local policies, strengthening infrastructure and raising awareness among the population. These actions are important for reducing the vulnerability of the municipality to climate change and ensuring sustainable development of the region.

1.2 Main objectives of the project

The project *"Towards Climate Resilience: Assessing Silistra's Climate Challenges and Solutions"* aims to address the municipality's pressing climate vulnerabilities through a structured, participatory approach guided by the CLIMAAX Handbook.

- Objectives and Significance

The main objective of the project is to enhance the resilience of the Silistra municipality to climate change by better understanding, preparing for and managing the climate risks, increasing risk knowledge and awareness, supporting informed decision-making, empowering local communities, and facilitating the development and implementation of robust climate adaptation policies.

Specific objectives

The specific objectives of the project are to:

- ✓ Increase risk awareness by analyzing climate data and disseminating findings to stakeholders.
- ✓ Support informed decision-making through evidence-based recommendations and workshops.
- ✓ Empower local communities with participatory research, capacity-building workshops, and awareness campaigns.
- ✓ Review and implement municipal strategic documents like the disaster risk reduction programme, to mitigate climate risks and enhance climate resilience.
- ✓ Promote long-term sustainability and climate resilience by implementing and monitoring effective adaptation measures.

Silistra's flat terrain, reliance on agriculture, and proximity to the Danube River make it highly susceptible to climate impacts. A structured assessment will fill critical data gaps, enabling evidence-based decision-making. The limited technical expertise and fragmented risk communication hinder proactive adaptation. The project will support building local capacity to ensure sustainable implementation of resilience measures.

Additionaly, the current policies lack explicit climate adaptation targets. This alignment will ensure compliance with Bulgaria's National Climate Change Adaptation Strategy and unlocks access to EU funding.

On the community and economic level, the main risks - prolonged droughts and extreme floods threaten 42,079 decares of cropland and 18,000 residents.

Expected Benefits of Applying the CLIMAAX Handbook

The Handbook's methodology ensures consistency in risk assessment, combining historical data, climate projections (RCP/SSP scenarios), and stakeholder input. This reduces uncertainties in prioritizing hazards like river floods and soil erosion. The CLIMAAX approach fosters collaboration across sectors (e.g., agriculture, infrastructure). Workshops and participatory mapping sessions will bridge gaps between policymakers and vulnerable communities, ensuring inclusive adaptation planning. Phase 2 refinement using local datasets (e.g., GIS land-use maps, socioeconomic surveys) will produce granular risk profiles, highlighting hotspots like Kalipetrovo's floodplains and erosion-prone southern farmlands. The Handbook's alignment with EU standards (e.g., Green Deal) ensures Silistra's updated Disaster Risk Reduction Programme meets transnational resilience benchmarks, enhancing eligibility for EU funding. By embedding CLIMAAX tools into municipal workflows, Silistra will establish a replicable model for continuous risk monitoring, adaptive governance, and community-led resilience initiatives.

1.3 Project team

The team working on the project includes:

- Teodor Velikov, Project Coordinator, European Programs and Projects Dept., Silistra Municipality
- Valentina Ivanova – Financial Expert, Silistra Municipality
- Lilia Traianova – Environmental Expert, Silistra Municipality
- Irina Todorova – Environmental Expert, Silistra Municipality
- Prof. Dr. Peter Nozharov - External expert, Climate, Air, Water Research Institute, Bulgarian Academy of Sciences
- "D and D Consulting" Ltd., Subcontractor

1.4 Outline of the document's structure

This report contains an introduction, objectives and project team and three main elements: an climate risk assessment (CRA) of for the Municipality of Silistra, drawing conclusions based on this assessment, and an assessment of progress and contribution to the implementation of future project phases.

The climate risk assessment contains:

- ✓ Defining the scope of the climate risk assessment with objectives (desired results of the analysis), context (implementation conditions) and stakeholders.
- ✓ The examination of risks with the main hazards, exposures and vulnerabilities for the municipality that are most apparent or of concern to key stakeholders and the general public.
- ✓ Risk analysis with the selected risk workflows from the CLIMAAX Handbook applied to the municipality and which hazard, exposure and vulnerability data are used.
- ✓ Preliminary key findings from the risk assessment, including:
    - Severity findings - how serious the risk is, given historical and current trends or potential impacts
    - Urgency findings - when these risks will have a major impact and when action should be taken to minimize damage.
    - Availability of capacity - what climate risk management measures the municipality has already put in place, including financial, social, human, physical and natural aspects.
- ✓ Preliminary monitoring and evaluation of the lessons learned in the first phase of the climate risk assessment and what feedback has been received from stakeholders and which other stakeholders should be included in the next stage of the analysis.

The conclusions on climate risks include the main conclusions reached at this stage of the project, as well as the main key findings. The assessment of progress and contribution to the implementation of future stages of the project includes a description of the relationship between the achieved results and the planned activities for the next stages with key performance indicators and objectives, and the actions taken to achieve them according to the municipality's project plan.

2 Climate risk assessment – phase 1

2.1 Scoping

2.1.1 Objectives

The main objective of conducting a multi-risk assessment is to identify key climate threats, the degree of exposure and vulnerability to them, applicable to the municipality of Silistra. The project team summarizes in this report how the CLIMAAX methodology can be adapted to the local climatic, geographical, economic and social context, taking into account the opinion of the stakeholders. The project and this report contribute to increasing knowledge and understanding of climate change issues and promote informed decision-making in the municipality of Silistra. As a result, the municipal authorities, citizens and businesses are better prepared to anticipate, prevent and respond to extreme climate events, through better disaster risk management and the development of strategic measures for climate adaptation. In accordance with the competence of the municipal authorities, they can adopt or amend specific plans, programs and measures for climate adaptation.

A key challenge for the project is to present the analysis of the main climate risks for the municipality in a way that is accessible to municipal authorities and the public, and not abstract and complex to perceive and take concrete actions. This is especially important against the backdrop of climate skepticism, which affects both politicians and administration. and the public. Gathering additional information to complement CLIMAAX's forecast data on the main risks can also be a challenge.

2.1.2 Context

The assessment and management of climate risks in the municipality of Silistra is determined by the competence of the municipality to ensure the protection of life and health of the population, the protection of the environment and property in the event of disasters under the Disaster Protection Act and the implementation of the municipal disaster protection plan, as well as other strategic documents such as the Municipal Integrated Development Plan of the Municipality of Silistra 2021-2027 (MIDP). MIDP determines measures for adaptation to climate change and for reducing the risk of natural disasters. Based on the analysis in MIDP, the most important problems and risks for the municipality have been identified: natural risks, the presence of risk territories and zones, an analysis and assessment of the state of the energy infrastructure, renewable energy and energy efficiency in the municipality has been made.

The main risks related to climate change are determined to be the danger of floods, erosion, landslides and the risk of problems with drinking water supply as a result of droughts. Silistra District stands out with the largest increase in precipitation in the country – 162% by 2017. Silistra Municipality falls into the Danube region (coast of the Danube River) with a high risk of flooding with 10 to 20% of the territory under threat. The Danube River embankment, located on the territory of the municipality, is 22 km long. The critical overflow point is 785 cm. The North Central Region is also in second place in the country, where Silistra also falls, with the most significant development of landslide processes. The municipalities located along the high Danube bank, as well as those on the right banks of the Danube tributaries, are most affected by landslide processes. The activation of landslides, in turn, is directly related to climate change and, above all, to intense precipitation.

In addition to the municipal disaster protection plan and the PIRO, the municipality also adopts other regulatory and strategic documents such as the Regulation on the rules and norms of fire safety on the territory of the Municipality of Silistra, the Regulation on the construction, maintenance and protection of the green system of the Municipality of Silistra, the Regulation on waste management on the territory of the Municipality of Silistra and the Waste Management Program 2021-2028. The Disaster Protection Plan of the Municipality of Silistra corresponds and is coordinated with the Disaster Protection Plan of the Silistra District and is an integral part of the National Disaster Protection Plan. It is also coordinated with the emergency plans of legal entities and sole proprietors under Art. 35 of the Disaster Protection Act that carry out their activities on sites of the first, second and third category under Art. 137 of the Spatial Planning Act (SPA), which pose a risk of disaster, located on the territory of the municipality, as well as with the disaster protection plans of legal entities and sole proprietors, with the exception of those under Art. 35 of the Disaster Protection Act, that carry out their activities in production buildings and public service buildings representing constructions of the first, second and third category under Art. 137 of the SPA.

The project addresses key climate risks for the municipality, including in the context of regional and national development, since the powers of the municipality and the financial resources at its disposal are not always sufficient for planning and implementing climate adaptation measures. In this sense, cooperation with the regional administration, as well as with central government bodies such as the Ministry of Environment and Water, is of particular importance.

At the national level, the National Strategy for Adaptation to Climate Change and Action Plan to 2030 outlines the framework for actions and priority areas for adaptation to climate change by 2030. The Strategy covers various sectors, including agriculture, forestry, biodiversity, water, energy, transport, urban environment, health and tourism. An example of a specific activity that municipalities should undertake according to the Action Plan to the Strategy in the Urban Environment sector under Strategic Objective 1 Improving the policy and legal framework for mainstreaming climate change adaptation is the review and updating of the requirements for the scope and content of the main instruments such as regional and spatial development schemes and plans and detailed development plans.

The National Strategy identifies key climate threats for Bulgaria such as floods (river and coastal), droughts and water resource shortages; forest fires; extreme weather events (storms, snowfalls, hail) and impacts on biodiversity and agriculture. These threats are also key for Silistra, with the exception of coastal floods and forest fires, due to the low share of forest massifs. In the short and medium term, blizzards and heavy snowfalls will continue to be the main source of disruptions to services for all types of transport.

The northern and northeastern parts of the country, where the Municipality of Silistra falls, are particularly susceptible to traffic disruptions in winter due to strong winds and snowfall.

2.1.3 Participation and risk ownership

One of the challenges of this project will be to present the results of the analysis of the main climate risks for the municipality in a way that is accessible to the public and business and placed in the context of their knowledge and capacity and to involve them in the next stage of collecting local data on climate risks, vulnerable sectors and territories and in taking specific measures and actions to achieve resilience and disaster response capabilities.

Important stateholders within the administration are the municipal administration, the Regional Directorate “Agriculture” - Silistra, the General Directorate “Fire Safety and Population Protection” at the Regional Directorate “Fire Safety and Population Protection” - Silistra.

In this sense, with the support of the municipality, the most active and relevant representatives of the public, business, the academic community and other stakeholders should be identified. MIDP Silistra and other strategic documents of the municipality provide more generally the profile of these stakeholders. E.g. there are two higher education institutions in Silistra: the Higher School of Agribusiness and Regional Development and a branch of the University of Ruse "Angel Kanchev".

Interested parties from the civil sector are the Women's Association "Ekaterina Karavelova", which works on children's issues, women's issues and social services; Association for a Creative and Educated Bulgaria - on international and European issues, policies and research, youth issues, policies and research and education; Durostorum-Drustar-Silistra - on the environment, development of local communities and neighborhood associations; DANUBE CLUB SILISTRA - on education; physical education and sports; NGO "Silistra 2030" with the main goal of transforming the city of Silistra, in the fields of education, entrepreneurship, domestic production and tourism, as well as other interested parties: Natural History Museum - Srebarna Biosphere Park, Natural Science and Mathematics High School "St. Kliment Ohridski", Industrial High School of Agriculture "Dobrudzha", National Community Center "Docho Mihaylov 1906", village Babuk, Community Centre "Probuda 1940", village of Kalipetrovo and Community Centre "Prosveta 1907, village of Prof. Ishirkovo.

Based on the analyzed climate risks, specific affected and vulnerable population groups are identified according to the specifics of the risk. For example, the risk of river floods affects people living in low-lying riverside areas in the municipality, as well as in poor neighborhoods, particularly vulnerable to flooding. Farmers near rivers can also suffer serious damage to their agricultural areas. Damage from intense rainfall can lead to serious damage to property and infrastructure, as well as interruptions in the provision of basic services, affecting local residents in urban and suburban areas with limited infrastructure capacities, as well as people living in areas with a high tendency to landslides. Other vulnerable groups are residents of areas with poorly built infrastructure, especially in old neighborhoods of Silistra, where sewage and drainage systems are not effective enough during intense rainfall.

Construction sites and businesses that do not have adequate flood protection systems are also at risk. Children and the elderly may face risks from flooding in homes and public buildings if the infrastructure is not adequately secured.

The Disaster Protection Act defines the obligations of executive authorities, legal entities, sole traders and individuals in the event of disasters and ensuring the protection of the life and health of the population, the protection of the environment and property. The Disaster Protection Plan of the Municipality of Silistra corresponds and is coordinated with the Disaster Protection Plan of the Silistra District and is an integral part of the National Disaster Protection Plan. It is also coordinated with the emergency plans of legal entities and sole traders.

The communication activities planned to communicate the results to the general public are a press conference, which has already taken place on October 24, 2024, 5 publications on the municipality's project website, as well as two communication actions to share the results with stakeholders, one seminar on March 28, 2025, and one final conference at the end of the project.

2.2 Risk Exploration

2.2.1. Screen risks (selection of main hazards)

Risk is determined by the combination of the probability of a hazard occurring and its impact. In Silistra, the risk is particularly high for floods and droughts, as these phenomena have a significant impact on the economy, infrastructure and population. In Silistra, the most developed economic sectors are agriculture and the food industry.

Agriculture

The Silistra region is known for its grain production (wheat, corn, sunflower), as well as fruit and vegetables (apricots, cherries, tomatoes, pepper). Thanks to the fertile land around the Danube River, the region has some of the best conditions for agriculture in Bulgaria.

Food industry

The milling industry, fruit and vegetable processing, as well as the production of dairy and meat products are highly developed, such as: "Zhosi" OOD: Located in the village of Chernolik, this enterprise is among the approved dairy processing companies for export to the EU. "Buldex" OOD: Located in the village of Belitsa and is also licensed to export dairy products to the European market.

There are enterprises in the region that export production to the EU, including "Fazerles" AD: Manufacturer of fiberboard used in the furniture industry and for packaging. About 90% of the company's production is intended for export. "ELICA PROcessing": manufactures equipment for processing seeds and cereals.

In view of the above, agriculture typical of the region is particularly affected by climate change, and the main climatic hazards for Silistra include:

1. Droughts and high temperatures:

Drought is among the main threats to agriculture in the region. In 2023, 27.17 ha of completely destroyed areas were documented due to a prolonged lack of precipitation. Yields of major cereals such as wheat have decreased compared to previous years, despite relatively high average values (6065 kg/ha).

2. Floods and heavy rains:

Heavy rains in certain periods have led to 14.78 ha of damaged areas. The excessive humidity increases the risk of plant diseases and yield losses.

2. Stormy winds:

In 2023, 73 cases of completely destroyed agricultural areas with a total area of 646.24 ha were reported, caused by hail and strong storms.

4. Snowfall and frosts:

101 completely damaged areas (641.33 ha) were registered due to spring and autumn frosts. This is especially critical for fruit growing, as spring frosts lead to loss of flowering and fruiting.

The hazards have been identified based on historical data and climate projections. The most significant are:

- ✓ Floods – High risk, especially in the areas around the Danube River
- ✓ Heavy rainfall
- ✓ Droughts – Increasing over time, affecting agriculture and drinking water
- ✓ Strong winds – causing material damage and power outages
- ✓ Snow storms – affecting the transport infrastructure.

Exposure refers to the elements that can be affected by the hazards. In Silistra, this includes:

- ✓ Population – According data from the General Register of Population as of June 15, 2024, 33,480 people live in the city at a permanent address, with vulnerable groups (elderly, socially disadvantaged) being the most at risk.
- ✓ Infrastructure – Residential buildings, transport network, water supply network, energy systems.
- ✓ Agriculture – Great importance for the local economy, but vulnerable to droughts and storms.
- ✓ Economic assets – Small and medium-sized enterprises, commercial areas.

The factors that increase Silistra's vulnerability include:

- ✓ Outdated infrastructure – Insufficiently adapted to increasing climate risks.
- ✓ Limited financial and technical resources – Complicate disaster prevention and response.
- ✓ Lack of sufficient adaptation strategies – Need for integration of climate policies into local planning.

Conclusions and challenges:

1. Reduction in the number of registered farmers:

In the recent years, the number of registered farmers in the district has been decreasing (3113 in 2020 to 2706 in 2023). This is due to increasing financial costs, higher minimum social security income and climate challenges.

2. Financial instability and need for support:

A large number of farmers apply for aid under various state and European programs. The increase in losses from climate disasters requires the expansion of insurance mechanisms for agricultural crops.

3. Need for climate change adaptation:

Invest in sustainable irrigation systems and water distribution. Promote resilient crops with better adaptation to droughts and temperature fluctuations. Improve monitoring and early warning of extreme weather events.

The current situation in Silistra is as follows:

According to a study by the "Institute for Market Economics" (IME) on the economic and social development of the districts in Bulgaria "Regional Profiles 2024". According to it, Silistra is again the district with the lowest score in the category of economic development. The gross domestic product per capita slows down its growth despite the low base, reaching 12.1 thousand BGN (compared to 26.0 thousand BGN in the country) in 2022. Salaries and pensions also continue to increase, but are still relatively low. The average annual gross salary of those employed under an employment and service contract is 14.8 thousand BGN (compared to 21.2 thousand BGN in the country). These indicators also determine the high level of poverty in the district. The share of the population living below the national poverty line reaches 25.6% (compared to 20.6% in the country), one of the highest in the country.

According to data from the Regional Commission for Grain Production, together with representatives of agricultural land users, a survey of 100% damaged areas was carried out as a result of natural disasters or adverse climatic conditions. Findings were issued as follows:

- ✓ 2 finding reports for 100% damaged areas of permanent crops and cereals for 14.78 ha caused by floods as a result of heavy rains;
- ✓ 73 finding reports for 100% damaged areas of permanent crops, vegetables and cereals as a result of storms and hail for 646.24 ha;
- ✓ 101 reports of findings for 100% damage of permanent crops for 641.33 ha from frost and frost;
- ✓ 5 reports of findings for 100% damage of cereal crops – 27.17 ha from drought;

The above-mentioned hazards mainly affect:

Agriculture

Agriculture is a key economic sector, but highly dependent on climatic conditions. Its vulnerability is increasing due to the lack of modern irrigation systems, limited access to technologies for sustainable agriculture and increasing production costs.

Infrastructure

Low density of first-class roads (11.3% compared to 18.5% on average for the country). Limited access to digital services and low percentage of households with the internet (70.6% compared to 87.3% for the country).

Small and medium-sized communities

High migration of young people from the region leads to demographic imbalance and reduced economic potential. Low level of urbanization – only 44.8% of the population lives in cities.

The geographical areas with increased risk include:

- ✓ Agricultural areas – vulnerable to droughts, erosion and hail.
- ✓ River and coastal areas – potential risk of flooding and soil degradation.
- ✓ Small settlements and peripheral municipalities – socio-economically vulnerable due to lack of infrastructure and demographic decline.

The risk study for the municipality of Silistra shows that the region faces multiple climate challenges that require urgent adaptation measures. Extreme climate events, such as droughts, hail and floods, affect not only agriculture, but also the socio-economic stability of the region.

The hazards to be covered in the risk assessment for Silistra, include:

The risk assessment for the Municipality of Silistra within the framework of CLIMAAX will focus on the most critical climate hazards affecting the region. Based on historical data, information from local stakeholders and climate projections, the following hazards have been identified as key priorities:

1. Floods – The Danube River poses a significant risk of river flooding, especially during heavy rainfall events. In addition, localised urban flooding can occur due to inadequate drainage infrastructure and extreme rainfall events.
2. Heavy rainfall – Intense rainfall can lead to flash floods, erosion and damage to infrastructure and agricultural areas. Strong winds and storms further threaten buildings and power supplies.
3. Droughts – Increasingly frequent and prolonged droughts affect water supplies, agriculture and ecosystem health. The decline in water resources is a serious problem for the local population and economy. Droughts can lead to reduced yields, shortages of drinking water and deterioration of the health of the population, especially among vulnerable groups.
4. Strong winds – High wind speeds can cause serious damage to buildings, power lines and transport infrastructure.
5. Snowstorms – They make transportation and access to services difficult in winter.

The available data and information on these hazards include:

The Municipality of Silistra has various data sources that will serve as the basis for the risk assessment:

- ✓ Historical climate data – Records of past extreme weather events, including floods, temperature extremes and droughts, reports and statistics;
- ✓ Hydrological and other data – Information on Danube river levels and discharges collected by national and regional institutions, data from various institutions, such as: Regional Directorate "Agriculture" - Silistra, General Directorate "Fire Safety and Population Protection" at the Regional Directorate "Fire Safety and Population Protection" - Silistra

- ✓ Geospatial and cadastral data – Mapping of risk areas, land use, soil characteristics and vegetation cover using GIS.
- ✓ Disaster reports – Damage assessments from previous climate events and emergency measures taken.
- ✓ Local expertise and public information – Opinions and experiences of local authorities, disaster response services and citizens on the impacts of climate change, insurance companies

To improve the accuracy and effectiveness of risk assessment, additional data needs to be collected:

- ✓ Precise climate projections – Localised climate scenarios reflecting long-term trends in temperatures, precipitation and extreme events.
- ✓ Updated vulnerability assessments – Socio-economic and demographic data to identify the most at-risk groups and sectors.
- ✓ Impact assessment – Detailed analyses of past extreme events, including economic, environmental and social damages.
- ✓ Resilience of critical infrastructure – Information on the condition and resilience of transport networks, energy supply, water supply and drainage systems.
- ✓ Role of ecosystems in risk reduction – Data on the functioning of local ecosystems as a buffer against climate threats, such as floodplains and forests.
- ✓ Public attitudes and preparedness – Surveys and public discussions to assess the level of awareness, preparedness and adaptation needs.

2.2.2. Workflow selection

Silistra region is among the least developed regions in Bulgaria in both economic and social terms. Examining the key aspects of the system reveals critically important dependencies and interrelationships that can affect the assessment of climate risk and the resilience of the region.

Dependencies and critical interrelationships

1. Socio-economic dependencies:

An aging population combined with a low-educated working population hinders economic development. Lack of investment and low incomes lead to migration of young people to more developed regions, exacerbating demographic problems.

2. Transport and economy:

Insufficient road infrastructure hinders business activities and attracting new investments. Lack of adequate internet access limits the development of modern industries such as the IT sector.

3. Environment and climate dependencies:

A low percentage of forest areas makes the region vulnerable to flooding and erosion. Poor management of waste and water resources increases the risk of pollution and deterioration of the quality of life. The volume of waste generated is similar to the national average – 413 kg per person per year (compared to 445 kg per person in the country) in 2021. Due to the low level of urbanization, a relatively small share of the population lives in settlements with public sewage systems – 51.0% (compared to 74.8% in the country). Nevertheless, the entire sewage system in the district is connected to a treatment plant.

The share of forest territory in the district is low – 15% (compared to 33% in the country), and the share of disturbed territory is close to the average – 0.41% (compared to 0.43% in the country).

Installed Renewable Energy Sources capacities are small – 0.40 kW per person (compared to 0.85 kW per person in the country).

Vulnerable groups

According to the National Climate Change Adaptation Strategy and the European Environment Agency (EEA) Report entitled "Unequal exposure and unequal impacts: social vulnerability to air pollution, noise and extreme temperatures in Europe", the main vulnerable groups are: children and the elderly, people with chronic diseases, socio-economically vulnerable people, those living in poverty, as well as people with harmful habits (alcohol, drug and tobacco use).

The main vulnerable groups and impacts on them in the municipality of Silistra, which were identified in this report, are the poor, the elderly and children, who are more vulnerable to environmental risks such as air pollution, noise pollution and extreme temperatures.

1. Children and the elderly

Children are more sensitive to heat waves and extreme temperatures, which are becoming more frequent in the region. High temperatures can lead to heat stress, dehydration and worsening of chronic diseases. Older people, especially those with cardiovascular and respiratory diseases, are at increased risk of complications due to heat, as well as diseases caused by air pollution.

2. People with chronic diseases

Silistra municipality has a high incidence of cardiovascular and respiratory diseases, which are aggravated by extreme weather conditions. Polluted air, increased levels of allergens and frequent temperature fluctuations adversely affect the health of these people.

3. People with low socio-economic status and living in poverty

Low-income individuals often live in buildings with poor insulation, which increases the risk of heat or cold stress. They also have limited access to quality healthcare and preventive measures against climate risks. Some neighborhoods lack adequate infrastructure to protect against natural disasters, such as floods and extreme temperatures.

4. People with harmful habits (alcohol, drugs, smoking)

These individuals are at higher risk of chronic diseases that are exacerbated by climate change. Smoking and alcoholism worsen respiratory and cardiovascular problems, making them more vulnerable to air pollution and extreme temperatures, which have recently been a feature of the municipality.

5. Outdoor workers (agricultural and construction workers, utility workers)

6. Ethnic minorities (Roma communities, marginalized groups)

7. Persons with disabilities

8. Women (especially single mothers and elderly women living alone)

9. Pupils and students (education system and climate change)

10. People living in low-lying and at-risk areas (floods, landslides)

The Municipality of Silistra faces significant challenges related to climate change, with some groups being particularly vulnerable due to socio-economic and health factors.

In the context of climate risk assessment and work streams (River Floods, Heavy Rainfall, Drought, Snow, Wind), vulnerable groups are those most at risk from the effects of different climate events. For them, documents containing information on social, economic and infrastructural vulnerabilities, as well as information on existing policies and adaptation strategies, are taken into account.

The selected workflows to test the CLIMAAX methodology in this report are:

Workflow #1 River Floods

In the event of floods, these groups can suffer major damage to their property and farmland. The risk is particularly high in autumn and spring, when rivers tend to overflow.

- ✓ People living in low-lying riverside areas in the municipality, as well as in poor neighborhoods, are particularly vulnerable to flooding. These communities usually lack adequate flood protection and have limited resources to cope with the consequences of the disaster.
- ✓ Farmers near rivers in the municipality also suffer serious damage to their farmland, especially if flood protection is not provided.
- ✓ Small businesses dependent on rivers for irrigation or transportation.

Workflow #2 Heavy Rainfall

Floods, landslides and other consequences of heavy rains can lead to serious damage to property and infrastructure, as well as disruptions in the provision of essential services. Local residents in urban and suburban areas with limited infrastructure capacities, as well as people living in areas with a high tendency to landslides.

- ✓ Residents of areas with poorly built infrastructure, especially in old neighborhoods of Silistra, where sewage and drainage systems are not sufficiently effective during intense rainfall.
- ✓ Construction sites and enterprises that do not have adequate flood protection systems.
- ✓ Children and the elderly, who may face risks from flooding in homes and public buildings if the infrastructure is not adequately secured.

2.2.3. Choose Scenario

The selection of appropriate scenarios for the Silistra region should take into account climate change, socio-economic factors such as demographic trends and economic activities (including agriculture), as well as the available scenarios within CLIMAAX. Silistra is a region with a strongly agricultural economy, which makes it extremely vulnerable to extreme climate events with a focus of this document on River Floods and Heavy Rainfall risks.

1. Relevant scenario assumptions for the region

Climate change

- ✓ Short-term (5 years): Increasing extreme weather events such as intense rainfall, droughts and heat waves are expected. The risk of flooding remains high due to changes in the river levels of the Danube.
- ✓ Medium-term (20-30 years): Forecasts indicate longer and more severe droughts, which will affect the agricultural sector. Temperatures will rise, which may increase the frequency of forest and field fires.
- ✓ Long-term (50-100 years): A significant increase in average temperatures is expected, leading to lasting changes in ecosystems, reduced water resources and changes in agricultural practices.

Socio-economic trends

- ✓ Demographic changes: The population of Silistra is decreasing, with young people migrating to larger cities or abroad. This may lead to labor shortages in agriculture and other sectors.
- ✓ Economic development: The main economic activities include agriculture, which is vulnerable to climate risks. There is a trend towards expanding sustainable agricultural practices and seeking irrigation solutions.
- ✓ Infrastructure changes: Investments in climate change adaptation will be crucial, including improving water supply infrastructure and strengthening the levees along the Danube.

Based on the provided workflows and the general context of climate change, the following scenario assumptions are relevant:

Increased Frequency and Intensity of Extreme Precipitation:

Climate models predict an increase in heavy rainfall events, which can lead to flash floods and exacerbate river flooding. The "Extreme precipitation critical thresholds" workflow highlights the importance of understanding these thresholds for local areas.

Changes in Danube River Flow:

Changes in precipitation patterns in the Danube River basin can affect river flow, leading to higher peak flows and increased flood risk. The "River flooding" workflow emphasizes the importance of hydrological modeling to assess these risks.

Urbanization and Land Use Changes:

Urban development can increase runoff and exacerbate flood risks. Changes in agricultural land use can also affect runoff and soil erosion.

2. Useful scenarios within CLIMAAX for the region

High-Resolution Precipitation Scenarios:

Scenarios that provide detailed information on future precipitation patterns at the local level are crucial for assessing flash flood risks.

Danube River Flood Scenarios:

Scenarios that model future river flow patterns and flood inundation areas are essential for managing river flood risks.

Combined Flood Risk Scenarios:

Scenarios that consider the combined effects of heavy rainfall and river flooding are needed to assess the overall flood risk.

Urban Development Scenarios:

Scenarios that model the effects of future urban development on flood risks can help inform urban planning decisions.

More specifically the following scenarios available within CLIMAAX can be applied to Silistra:

- ✓ Representative Carbon Concentration Pathways (RCPs):

RCP2.6 and RCP4.5: These scenarios project moderate levels of global warming, associated with medium to high efforts to reduce carbon emissions. They would be useful for analyzing climate risks such as floods, heavy rains and drought that could affect Silistra, taking into account the possibility of limiting climate change through sustainable policies.

RCP8.5: This is a high-emissions scenario that projects severe consequences of global warming that could lead to intense climate events such as increased rainfall, extreme temperatures and droughts. This scenario would be useful for assessing future risks if serious climate policies are not taken.

- ✓ Shared Socio-Economic Pathways (SSPs):

SSP1 - "Green Pathway": This scenario emphasizes sustainable development through investments in green technologies, low population growth and sustainable resource management. In Silistra, such a scenario could reduce climate risks through adaptation, leading to better water management, sustainable agriculture and infrastructure innovation.

SSP2 - "Shared Development Pathway": This scenario assumes moderate population growth and technological innovation, which are, however, slower. For Silistra, such a scenario would be useful for assessing sustainable adaptation to increasing climate risks such as higher water levels and extreme climate events.

SSP3 - "Hard Road": This is a scenario that explores a future with high population growth and weak efforts to develop technologies and sustainable management. In this scenario, Silistra would be more vulnerable to climate risks, as the lack of investment in green technologies and unsustainable agriculture would increase the risks of floods and droughts.

3. Adaptation options:

The following adaptation options exist for the Municipality of Silistra to enable the development of the comprehensive flood risk management plan:

- ✓ Flood defense infrastructure: Construction and maintenance of levees, flood walls, and other flood control structures and improving drainage systems.
- ✓ Early warning systems: Development and implementation of early warning systems for both river floods and flash floods.
- ✓ Land use planning: Zoning regulations to restrict development in flood-prone areas and promoting sustainable urban drainage systems.
- ✓ Disaster preparedness and response: Developing evacuation plans and providing emergency response resources and increasing public awareness of flood risks.
- ✓ Ecosystem-based adaptation: Restoring wetlands and floodplains to increase natural flood storage and promoting sustainable land management practices to reduce runoff.
- ✓ Water management improvements: Improvements to water management infrastructure to increase the capacity to handle large amounts of water.

2.3 Risk Analysis

2.3.1 Workflow #1 - River Floods

Table 2-1 Data overview workflow #1

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
River flood hazard maps for historical climate from JRC	Flood damage curves from JRC	Land use dataset from JRC	Economic damage estimate
River flood hazard maps for climate scenarios from Aqueduct Floods	Flood damage curves from JRC	Land use dataset from JRC	Economic damage estimate

2.3.1.1 Hazard assessment

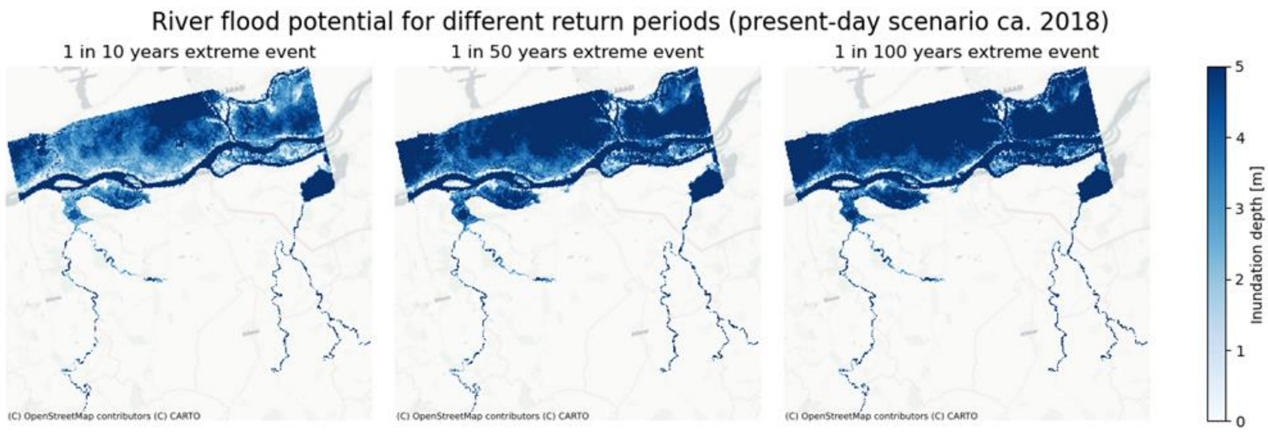

Figure 3 – River flood potential for different return periods

Figure 3 shows the potential for flooding in the municipality of Silistra during events with different return periods for the current climate (ca. 2018). The most affected by the floods will be the Aydemir lowland, including the area of Srebarna Lake, which rises very slightly above the level of the Danube River. The area of the lowland is 34 km^2, which is about 6.6% of the area of the municipality of Silistra. In the case of an extreme event with a return period once in every 10 years, flooding of the order of 1-2 meters can be expected there. In the case of an extreme event with a return period once in every 50 years, the expected flooding depth increases to 3-4 meters, and in the case of an extreme event with a return period once in every 100 years, the flooding depth almost everywhere in the Aydemir lowland will be about 5 meters. Some dry valleys in the municipality (Demirkulak, Kanagyol, Harsovska River) may also be flooded during a certain extreme event, regardless of its probability of occurrence.

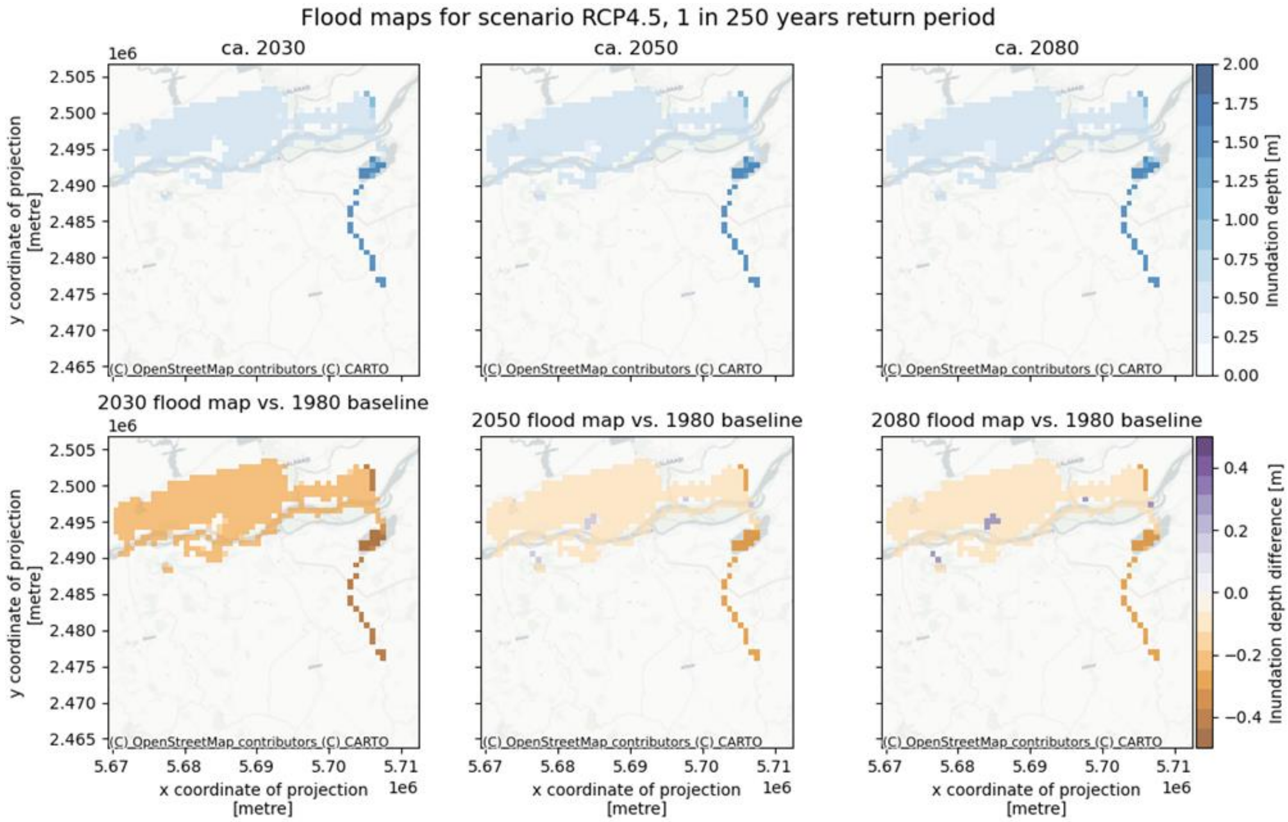

Figure 4 – Flood maps for scenario RCP4.5

The top three panels of Figure 4 show the depth of flooding in the municipality of Silistra, respectively, in 2030, 2050 and 2080 using the RCP4.5 scenario. In general, this is the moderate scenario for the future increase in greenhouse gases and air temperature. The return period of the extreme event is once in every 250 years. Figure 4 is different from Figure 3, which is due to the lower resolution of the models and the averaging of the results from multiple models. The top three panels show that the affected parts of the municipality of Silistra will be the Aydemir lowland and Harsovska River valley. In the Aydemir lowland, flooding of up to 0.5 meters is expected in such an event, while in the Harsovska River valley this flooding will be up to 1.5 meters. The bottom three panels of Figure 4 show how the flood height will change for an event with a return period once in 250 years in 2030, 2050 and 2080 compared to the 1980 baseline using the RCP4.5 scenario. During these future periods, the flood height in Silistra municipality will actually decrease by 0.2 to 0.4 m. This is related to the fact that this scenario predicts a decrease in precipitation in this part of Bulgaria. In 2050 and 2080, there are a few cells in the Srebarna lake area that show a slight increase in flood height.

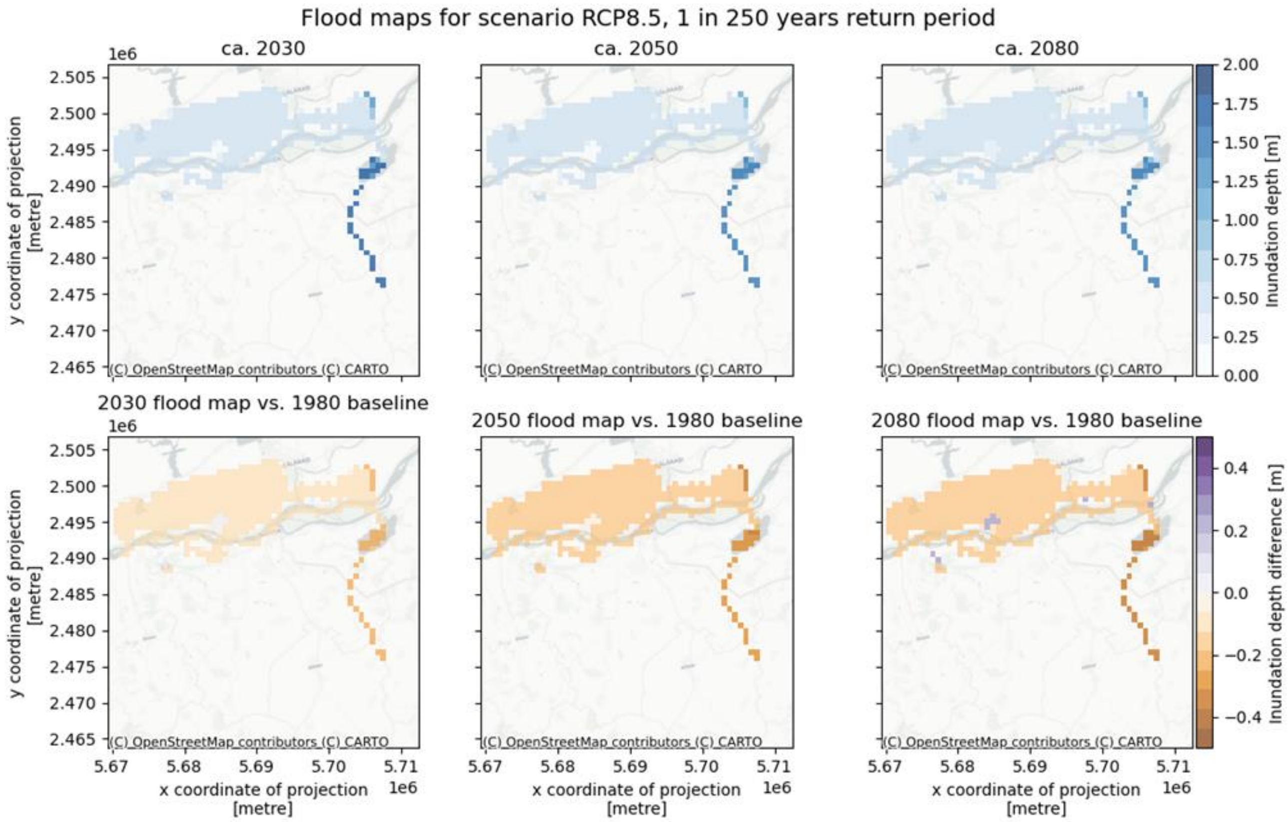

Figure 5 – Flood maps for scenario RCP8.5

The top three panels of Figure 5 show the depth of flooding in the municipality of Silistra, respectively, in 2030, 2050 and 2080 using the RCP8.5 scenario. This is the most negative scenario, which predicts the largest increase in greenhouse gases and air temperature by the end of the 21st century. The top three panels of this figure are similar to those of Figure 4 and show the height of flooding in 2030, 2050 and 2080 for an event with a return period once in 250 years. In this scenario, the Aydemir lowland and Harsovska River are most affected. In the Aydemir lowland, flooding of up to 0.5 m is expected, and in the Harsovska River valley - up to 1.5 m. When comparing 2030, 2050 and 2080 with 1980 it can be seen that in this scenario, the depth of flooding of the affected territories is expected to decrease by 0.2 to 0.4 m. This is due to the fact that this scenario also projects a general decrease in precipitation in the municipality of Silistra. In 2080, only two grid cells in the Srebarna Lake area show a certain increase in the depth of flooding during an extreme event with such a return period.

2.3.1.2 Risk assessment

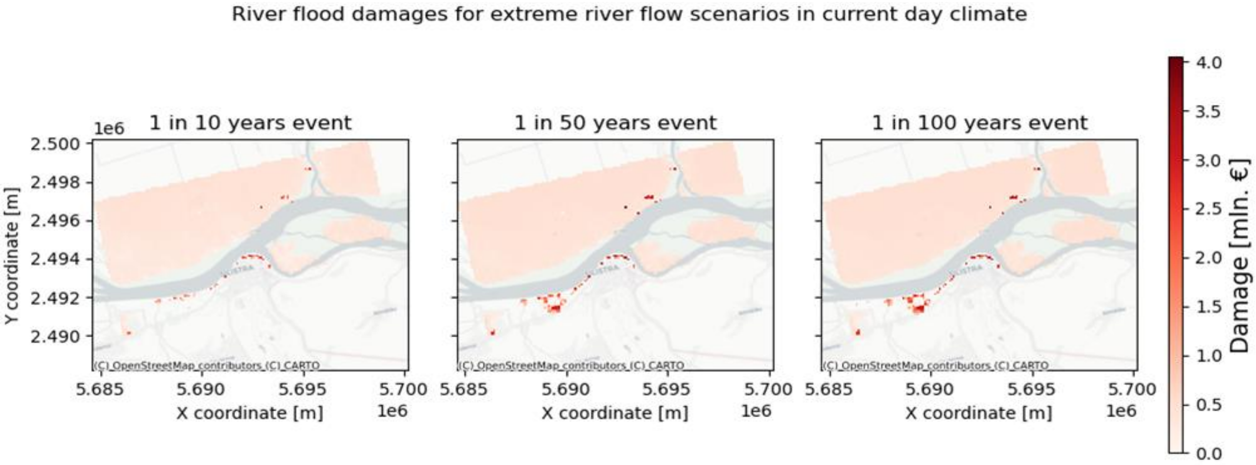

Figure 6 – River flood damages for extreme river flow scenarios in current day climate

Figure 6 shows the potential losses from floods with different return periods in the municipality of Silistra in the current climate. All three panels of the figure show that the territories of the Aydemir lowland and the dry valleys of the larger rivers in the region will be most affected. This fully coincides with the results of Figure 3. The losses from events with different return periods differ little. In the case of an event with a return period once in every 10 years, there will be losses of the order of 1 million euros in the Aydemir lowland. These losses increase significantly in the easternmost part of the lowland, reaching levels of 2-3 million euros. This is due to the fact that the large village of Aydemir is located there, as well as some industrial enterprises. These are prerequisites for greater damage from flooding, since people, buildings and infrastructure will be affected the most. In the case of an event with a return period once in 50 years, the territorial scope of the damage increases slightly, mainly in the eastern part of the Aydemir lowland and the adjacent Danube River basin. The damage expressed in monetary terms increases accordingly. In the case of an event with a return period once in 100 years, the area of the affected territories is almost the same as in the case of an event with a return period once in 50 years. Again, the most damaged areas are the eastern part of the Aydemir lowland and the industrial zone along the Danube River west of the city of Silistra where the losses from flooding can reach 3-3.5 million euros.

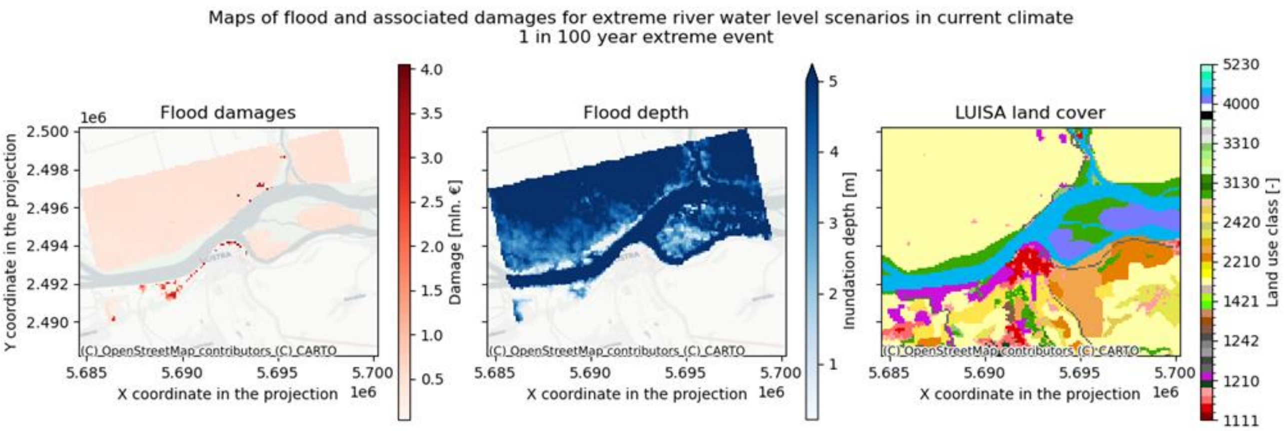

Figure 7 – Maps of flood and associated damages for extreme river water level scenarios in current climate

Figure 7 summarizes the results shown in the previous figures under conditions of current climate and a probability of occurrence of an extreme event once in 100 years. The first panel of this figure corresponds to the third panel of Figure 6, and the second panel to the third panel of Figure 3. The third panel of Figure 7 shows the spatial distribution of land cover in the municipality of Silistra. It clearly reveals the urbanized and industrial areas in the easternmost part of the Aydemir lowland, and further east along the Danube River to the border with Romania. It is their flooding that leads to the greatest damage in monetary terms.

2.3.2 Workflow #2 - Heavy Rainfall

Table 2-2 Data overview workflow #2

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
EURO-CORDEX dataset with workflow-defined settings of GCM, RCM, RCP, and time frames	Pre-calculated European datasets	Pre-calculated European datasets	Scenarios for frequency and magnitude of extreme precipitation events

2.3.2.1 Hazard assessment

The hazard assessment for heavy rainfall in Silistra follows the methodology outlined in the CLIMAAX Handbook. The workflow consists of several key steps:

1. Temporal Analysis of Extreme Precipitation

The annual maximum precipitation series were extracted from a selected pixel within the municipality. A Generalized Extreme Value (GEV) distribution was fitted to the annual maximum precipitation data to model extreme rainfall events.

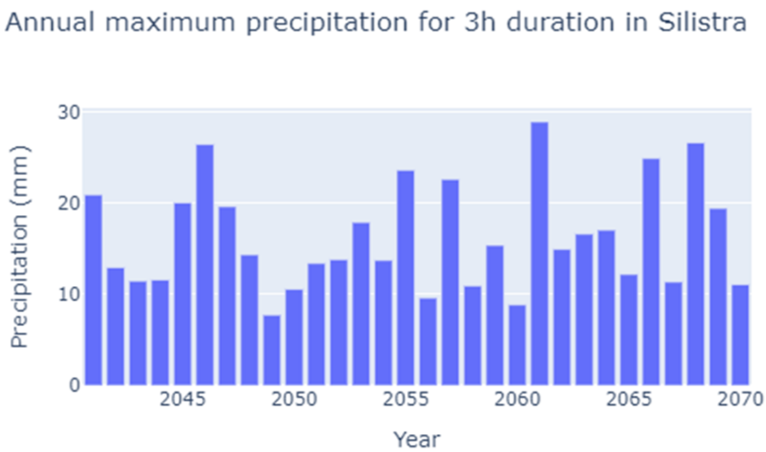

Figure 8 – Annual maximum precipitation for 3h duration in Silistra

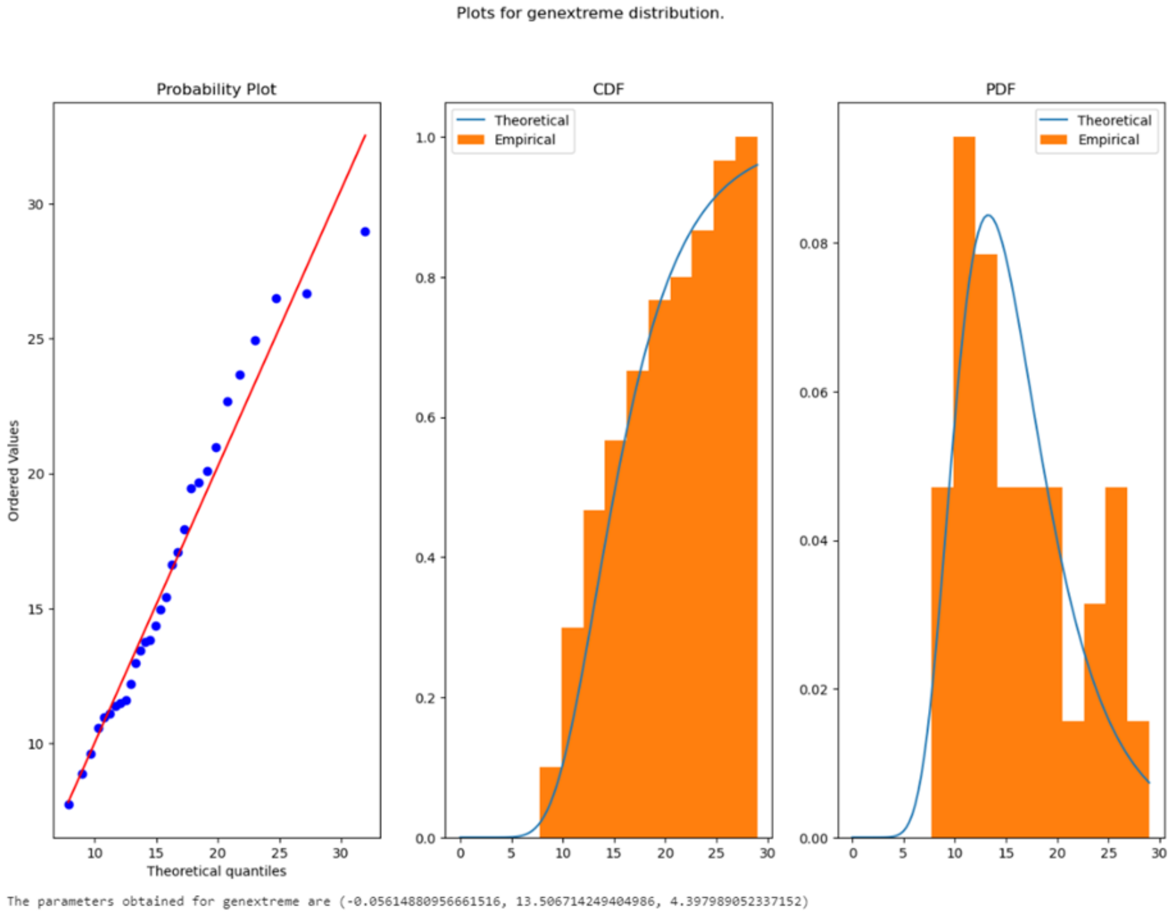

Figure 9 – Plots for genextreme distribution

2. Return Period Estimation

The expected precipitation values for different return periods (2, 5, 10, 25, 50, 100 years) were computed. This helps in understanding the frequency and magnitude of extreme precipitation events over time.

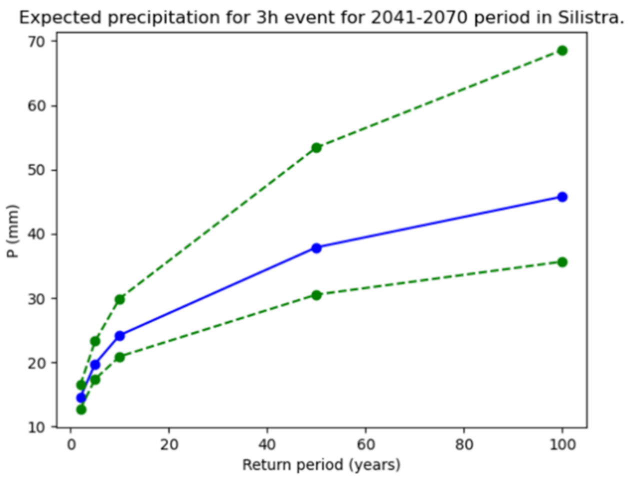

Figure 10 – Expected precipitation for 3h event for 2041-2070 period in Silistra

3. Spatial Analysis of Extreme Precipitation

Maps were generated to visualize extreme precipitation levels and their spatial distribution. The changes in extreme precipitation levels between historical and future scenarios were analyzed.

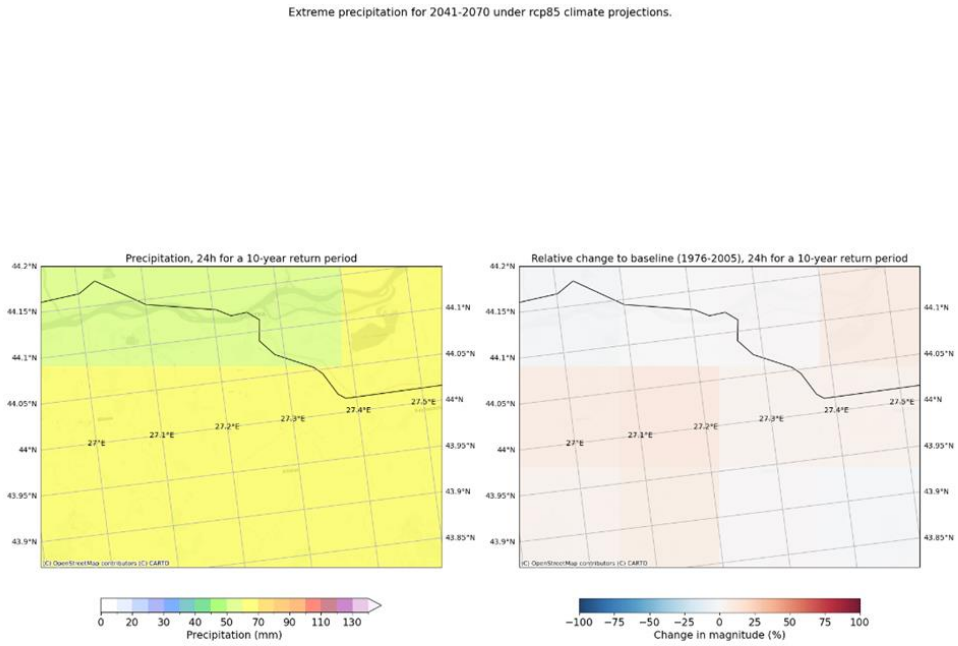

Figure 11 – Extreme precipitation for 2041-207 under RCP8.5 climate projections

4. Precipitation versus Frequency Curves

Graphs comparing historical and projected future precipitation trends were created to assess overall changes in heavy rainfall risks.

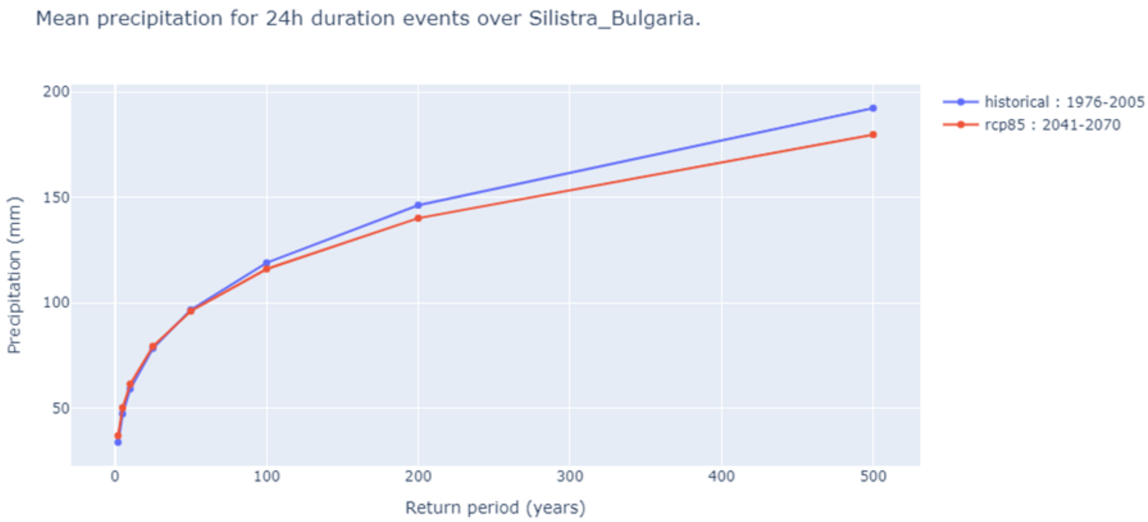

Figure 12 – Mean precipitation for 24h duration events over Silistra

5. Hazard Findings

Heavy rainfall is a significant hazard for the Municipality of Silistra, impacting people, infrastructure, buildings, and agriculture. The key findings from the analysis include:

- ✓ Heavy rainfall events are common in the current climate, predominantly occurring from April to October.
- ✓ Future projections indicate a mixed trend in heavy rainfall frequency:
    - o The southern and western parts of Silistra are expected to experience an increase in the frequency of extreme precipitation events.
    - o The eastern and northern parts may see a decrease in the occurrence of such events.

Overall, the risks associated with heavy rainfall will persist in the future, necessitating continuous monitoring and adaptive measures.

2.3.2.2 Risk assessment

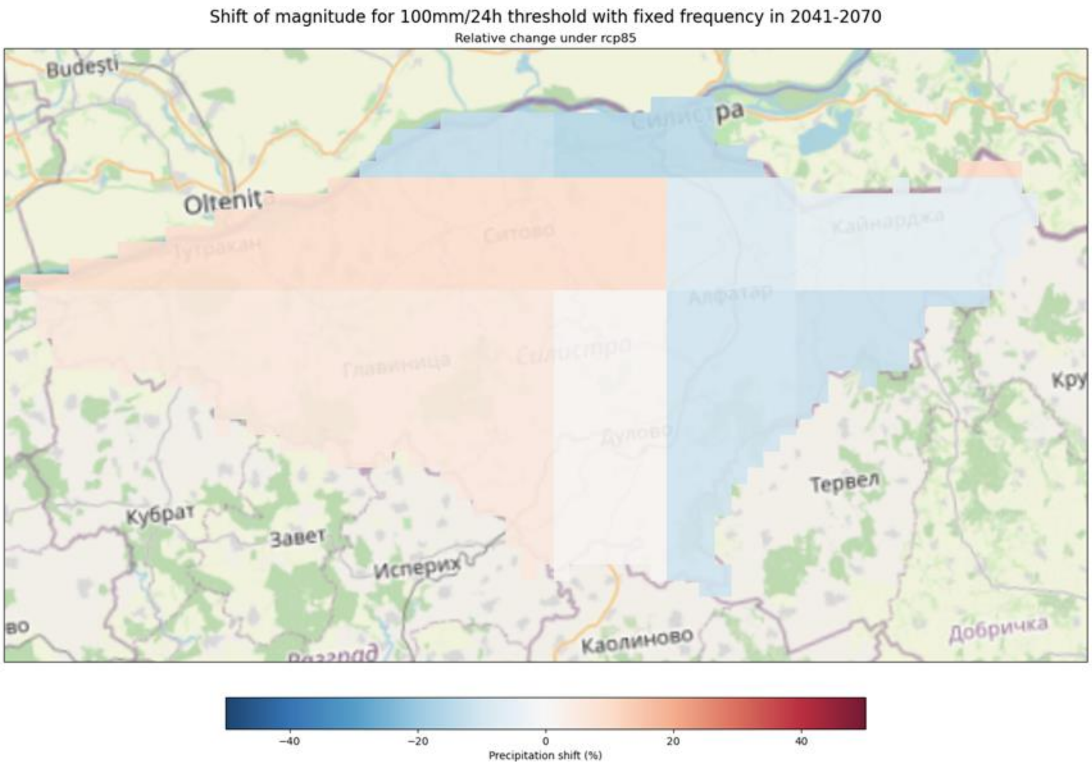

Figure 13 – Shift of magnitude for 100 mm/24h threshold with mixed frequency in 2041-2070

Figure 13 shows what change in the magnitude of the 100 mm per 24 hour threshold (fixed frequency) can be expected during the period 2041 – 2070 compared to the current period under the RCP8.5 scenario (the most unfavorable scenario with the largest increase in air temperature). In general, in the western and southern parts of the Silistra municipality, an increase of up to about 20%

is expected in this threshold. This means that if in the current period precipitation of 100 mm per day is occurring with a certain frequency, in the future period precipitation of 120 mm per day will occur with the same frequency. This means an increase in the frequency of intense precipitation, which increases the risk cases in this part of the municipality. At the same time, in the eastern and northern parts this threshold will decrease by up to about 10%. This means a decrease in the frequency of intense precipitation, which is a favorable trend. However, areas with a projection of increased precipitation intensity during the period 2041 - 2070 under the RCP8.5 scenario predominate in the Silistra municipality.

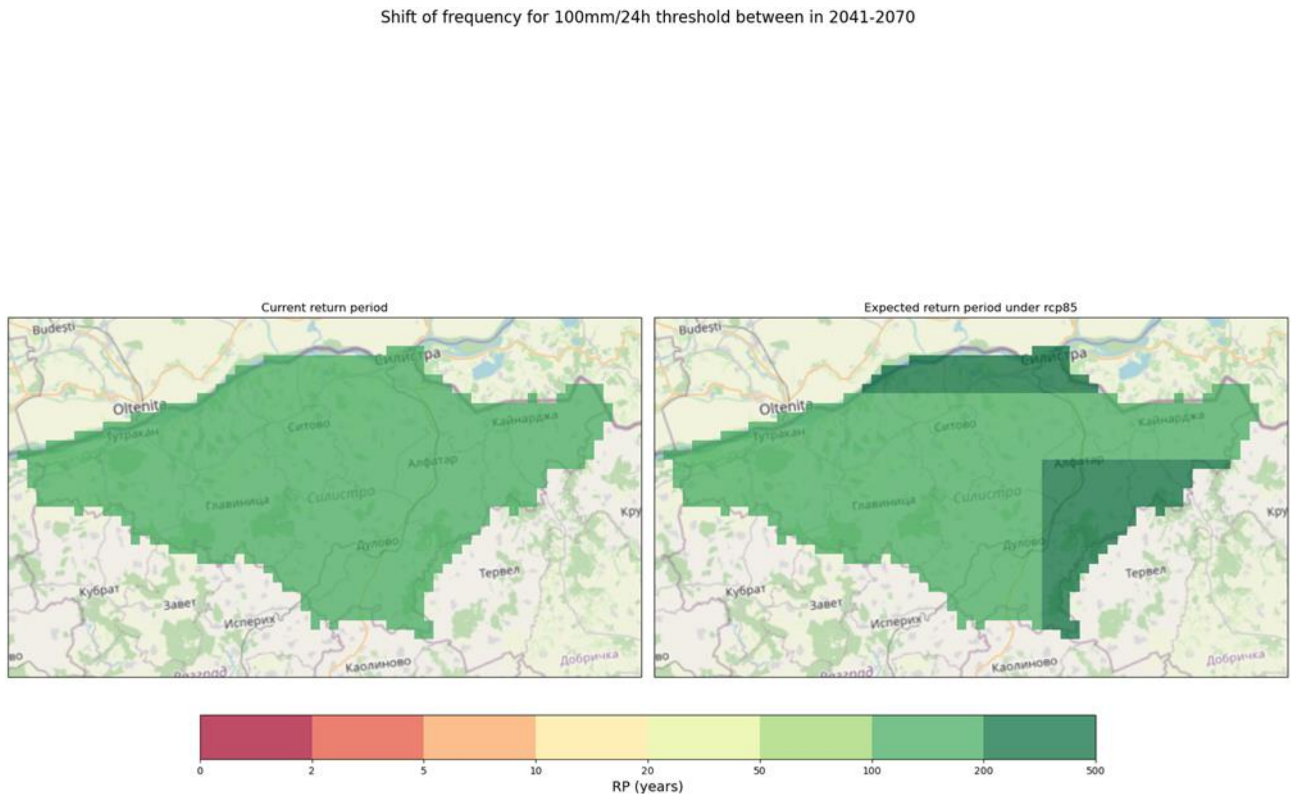

Figure 14 - Shift of frequency for 100 mm/24h threshold between 2041-2070

Figure 14 shows the change in the return period of precipitation with an intensity of 100 mm per day during the period 2041 – 2070 compared to the current period under the RCP8.5 scenario. The left panel of the figure shows the return period in the current period for precipitation of 100 mm per day, which is the same for the entire municipality and ranges from 100 to 200 years. The right panel of the figure shows the change in the return period in 2041 – 2070. It can be seen that in the northern and southeastern parts of the municipality of Silistra this return period is expected to increase, reaching a range between 200 and 500 years. This means a decrease in the frequency of precipitation with an intensity of 100 mm per day, which coincides completely with the results shown in Figure 6. However, it should be pointed out again that this is the smaller part of the municipality.

2.4 Preliminary Key Risk Assessment Findings

2.4.1 Severity

The preliminary analysis of some risks in the municipality of Silistra shows that the danger of floods is concentrated mainly in the areas of the Aydemir lowland and the dry river valleys. In the current climate, such phenomena can and do occur with a frequency of up to once in every 10 years. However, future scenarios show that the height of the flooding will decrease, which is related to the decrease in precipitation in the area. In the current climate, the greatest damage from floods is observed in the village of Aydemir, which is located in the easternmost part of the Aydemir lowland, as well as in the industrial zone of the city of Silistra, which is located west of it along the Danube River. This is related to the presence of people, buildings and industrial enterprises, which are more vulnerable and more expensive to restore.

Heavy rainfalls also pose a threat to the municipality of Silistra. They are typical for the current climate, causing significant damage to people, buildings, infrastructure, and agriculture. They occur mostly in the warm half of the year, from April to October. Future scenarios show mixed trends. In the southern and western parts of the municipality, an increase in the frequency of heavy rainfalls is expected, while in the eastern and northern parts the frequency should decrease. Overall, the risks of heavy rainfalls will remain important in the future. The findings suggest that heavy rainfall will remain an important hazard for Silistra, requiring proactive planning to mitigate its impacts. Increased rainfall in certain areas could lead to more frequent flash floods, erosion, and infrastructure damage. Therefore, adaptation strategies should focus on improving drainage systems, flood risk management, and early warning systems.

2.4.2 Urgency

The risk of flooding exists nowadays. Silistra Municipality borders the Danube River, which is one of the largest rivers in Europe. Its watershed is very large and the river level depends on meteorological processes with a very large spatial scale. There have been, are and will be high river waves. In this regard, the local population has taken various protective measures. The most effective is construction of dikes, which currently exist in Silistra Municipality. They largely mitigate the risk of flooding of large areas. Of fundamental importance is the maintenance of already constructed facilities and their possible upgrade in the case of an increase of the risk. However, future scenarios show a decrease in the height of flooding, which means that new flood protection facilities are not needed. However, it should be borne in mind that the Danube River's watershed is very large and Silistra Municipality must also take into account projections for the future climate in a large part of Europe. The positive thing about floods in the area of the Danube River is that the high wave most often starts from the upper or middle reaches and it takes a certain amount of time to reach the Silistra region, which provides opportunities for timely response and protection.

Heavy rainfalls are often sudden, difficult to forecast, and impact specific areas of the municipality unpredictably. Due to their frequency in the current climate, they represent the most dangerous risk for the population, buildings, infrastructure, and agriculture. Climate projections indicate an increase in heavy rainfall frequency in most parts of Silistra by the end of the century, making it essential to take preventive measures now. Over the past few decades, numerous heavy rainfall events have caused serious damage, with most measures taken only after the destruction had already occurred.

2.4.3 Capacity

The climate risk management measures that are already in place to tackle the above risks in the Municipality of Silistra, including financial, social, human, physical and natural aspects, with a focus on river floods and heavy rainfall, are as follows:.

The Municipality of Silistra is committed to participating in the implementation of national strategies for adaptation to climate change. This includes:

- ✓ Integrating adaptation measures into local policies and development plans, focusing on sectors such as water supply, energy and transport.
- ✓ Strengthening infrastructure, with a priority on water supply and energy infrastructure, to increase resilience to climate change, particularly in the context of risks from river floods and heavy rainfall.
- ✓ Raising awareness among the population about the risks and adaptation measures to climate change, with specific educational efforts on flood preparedness and safety measures during heavy rainfall events.

The Municipality is also implementing measures from the Energy Efficiency Program 2020-2025, which indirectly contributes to climate risk management by:

- ✓ Increasing energy efficiency and modernizing energy infrastructure, which can alleviate some of the pressure on resources during climate-related events.
- ✓ Improving the quality of energy services by modernizing district heating systems and using renewable energy sources.
- ✓ Training municipal specialists in energy management.
- ✓ Reducing pollution and improving the ecological environment, which can enhance the municipality's overall resilience to climate change impacts.

Furthermore, the Municipality's Integrated Development Plan (MIDP) 2021-2027 includes measures that directly and indirectly address climate change adaptation and disaster risk reduction, including:

- ✓ Development of ecological and sustainable agriculture and climate change risk management.
- ✓ Implementation of projects for improving irrigation systems and developing digital infrastructure for agricultural producers.
- ✓ **Strengthening of defenses against river floods**, modernization, reinforcement and construction of protective facilities to combat erosion and flood prevention. This is a key measure to address the identified risk of river floods along the Danube coast.
- ✓ Building capacity for actions of the responsible authorities and the population in the event of natural disasters, including specific protocols for responding to and managing heavy rainfall and flood events.
- ✓ Which opportunities may emerge from dealing with the respective risk? Consider financial, social, human, physical and natural aspects.

Dealing with climate risks, particularly river floods and heavy rainfall, presents several opportunities for the Municipality of Silistra:

Financial:

- ✓ Attracting investments in resilient infrastructure and green technologies designed to withstand and mitigate the impacts of floods and heavy rainfall.
- ✓ Improving energy efficiency to minimize the costs of recovery and maintenance after climate events.
- ✓ Developing financial and insurance instruments, as well as risk management funds, specifically tailored to address potential losses from floods and extreme weather.

Social:

- ✓ Raising public awareness and improving education on climate change, with a focus on community preparedness and response to flood risks and heavy rainfall events.
- ✓ Promoting public involvement in adaptation actions, such as volunteer programs for flood monitoring, drainage maintenance, and emergency response.
- ✓ Improving the quality of life of the population by creating a more sustainable and resilient community, with reduced vulnerability to climate-related disruptions.

Human:

- ✓ Building capacity for adaptation to climate change at all levels, including training for municipal staff and emergency services in flood management and urban drainage solutions.
- ✓ Training specialists in fields such as hydrology, civil engineering, and disaster management, to enhance the municipality's ability to address flood and heavy rainfall risks.

Physical:

- ✓ Strengthening infrastructure, such as drainage systems, flood defenses, and early warning systems, to increase resilience to river floods and heavy rainfall.
- ✓ Implementing measures for sustainable water and waste management to reduce the risk of contamination and pollution during flood events.
- ✓ Rehabilitating the street network with ecological solutions that improve water drainage and reduce the risk of urban flooding.

Natural:

- ✓ Sustainable management of natural resources and protection of ecosystems, with a focus on maintaining the natural floodplains and riverbanks to mitigate flood risks.
- ✓ Promoting ecological agriculture and organic farming practices that enhance soil health and reduce runoff, which can help manage the impact of heavy rainfall.
- ✓ Reducing pollution and harmful emissions into the atmosphere to minimize the overall contribution to climate change, which exacerbates the frequency and intensity of extreme weather events.

2.5 Preliminary Monitoring and Evaluation

From the first phase of the climate risk assessment task, we learned that successful implementation of the CLIMAAX methodology requires a detailed analysis of available data, active engagement of stakeholders, and adaptation of standard procedures to the local context. We also understood that the assessment process must be flexible to reflect the specific climate risks and socio-economic conditions of the respective region.

Among the main difficulties we faced were:

- ✓ Lack of data – In some cases, there was a lack of sufficiently detailed and reliable local data on key risk factors such as precipitation, temperature, infrastructure vulnerability, and social indicators.
- ✓ Inconsistencies between different data sources – The available data were often collected using different methodologies, making it difficult to compare and integrate them into a single risk assessment.
- ✓ Limited capacity of local administration – The teams involved in the risk assessment had limited expert and technical capacity for analysis and work with GIS tools.
- ✓ Difficulties in engaging stakeholders – Despite efforts to involve different institutions and local communities, the participation process was challenging due to different levels of awareness and interest.
- ✓ Adaptation of the methodology – The implementation of the CLIMAAX framework required further adaptation to specific local conditions, especially regarding the selection of risk scenarios and workflows.

The challenges we encountered when working with the CLIMAAX methodology include the differences in the way data and maps are generated across different notebooks. These differences include:

- ✓ **Different result granularity** – in some notebooks, the results are at the regional level, in others at the district level, and in some cases at the city and municipal level.
- ✓ **Different ways of input of coordinates.**
- ✓ **Different base maps** – for extreme precipitation notebooks, OpenStreetMap.Mapnik maps are used; for flood notebooks, *CartoDB.Positron* maps are applied; and for snow-related notebooks, base maps are missing.
- ✓ **Different projections** – in some cases, the projection is set to *Orthographic(0, 35*), while in others, it is *RotatedPole(pole_latitude=39.25, pole_longitude=-162*).

Due to these specifics, the generated maps do not follow a unified design and can differ significantly.

Feedback from stakeholders

What was recommended to us during the stakeholder meetings was the need for more detailed local data. Representatives of the local administration and environmental experts noted that the existing data are not always accurate or up-to-date enough, which limits the reliability of the climate risk assessment. They recommended additional efforts to collect and verify data, including through new monitoring systems and cooperation with scientific institutes.

- ✓ Desire for more active involvement of the local community – Civil society organizations and businesses emphasized that more local residents and entrepreneurs should be involved in the process, especially those who are directly affected by climate risks (e.g. farmers, tourism operators, livestock breeders, etc.).

- ✓ Better coordination between institutions – Some participants noted that communication between different institutions (municipalities, regional structures, national agencies) is not always effective enough. They suggested the creation of a coordination mechanism or working group for better interaction.

- ✓ Adapting results to practical needs – Businesses and infrastructure operators expressed the view that the analyses and recommendations should be more applicable in real conditions and offer concrete adaptation solutions that can be easily integrated into development plans.

Additional stakeholders needed for the next iteration

For the next phase of the analysis, other key actors should be included:

- ✓ Representatives of the private sector, especially from sectors such as tourism, agriculture, construction and energy.
- ✓ Research institutes and universities, which can provide more in-depth analyses and modelling of climate risks.
- ✓ NGOs and environmental experts, which can support community engagement and sustainable solutions.
- ✓ Civil society organisations and local initiatives, which can ensure wider participation and awareness among the population.

The inclusion of these additional stakeholders will contribute to a more comprehensive and actionable analysis that reflects both the scientific evidence and the practical needs of local communities.

New data availability and needs

During the first phase of the climate risk assessment, various types of data were collected and analyzed from available sources, including climatic, hydrological, geospatial and socio-economic data. However, the process revealed some limitations and gaps that require further collection and verification of information.

New or additionally available data:

- ✓ Thanks to collaboration with scientific institutions and international organizations, higher quality satellite data on land cover, vegetation and surface water changes can be made available.
- ✓ Socio-economic indicators: Based on statistical data on vulnerable groups, economic activities and critical infrastructure, better models of impacts on local communities can be made.
- ✓ Feedback from local stakeholders: Surveys and interviews with residents and businesses provided additional information on the real impacts of climate change on local ecosystems and economic sectors.

Despite the new data, several key challenges still exist that require additional resources, expertise and research.

- ✓ More detailed geospatial data – High-resolution GIS data on land use, hydrographic features and vulnerable areas.
- ✓ Critical infrastructure data – Better mapping of sites such as hospitals, schools, transport networks and water supply systems to assess their exposure to climate risks.
- ✓ Economic impact analysis – Detailed estimates of financial damages from extreme weather events (e.g. losses to agriculture, tourism, public services).
- ✓ Historical climate disaster data – Information on previous events such as floods, droughts and storms to improve modelling of the likelihood and severity of future risks.
- ✓ Development of localised climate risk scenarios – Integrating global and European climate models with local conditions to make more realistic forecasts.
- ✓ Secondary effects analysis – Studying the interrelationships between different risks (for example, how drought increases the risk of wildfires or how floods affect soil erosion).
- ✓ Social vulnerability assessment – A deeper analysis of the socio-economic impacts of climate change on different demographic groups, including the elderly, low-income households and rural communities.

3.Conclusions Phase 1- Climate risk assessment

Phase 1 of the CLIMAAX Climate Risk Assessment for the Municipality of Silistra focused on the implementation of the Common Methodological Framework of the program. The main objective of this stage was to provide a detailed understanding of the main climate risks affecting the region, to analyze existing data and to identify key challenges and needs for future activities.

Main conclusions from Phase 1

The phase provided an opportunity for a structured identification and analysis of the main climate threats affecting the territory of the municipality, including:

- ✓ River floods - increased risk, especially in the coastal and low-lying parts of Silistra.
- ✓ Heavy rainfall - increased frequency and intensity, leading to soil erosion and compromising urban infrastructure.

Several key challenges were addressed during this stage:

- ✓ Data collection and processing – The use of available climatic, hydrological and geospatial data allowed for the creation of a detailed picture of climate risks.
- ✓ Application of the CLIMAAX methodology – A framework for risk analysis and assessment was provided, based on scientifically sound indicators.
- ✓ Stakeholder engagement – The municipality managed to draw attention to the issue by consulting with various stakeholders, including business representatives, local administration and experts in the field.

Despite the positive results, several challenges were identified that will require further attention:

- ✓ Insufficient local data – The lack of sufficiently detailed and long-term local measurements makes it difficult to model future climate scenarios. Better quality data is needed to refine forecasts.
- ✓ Limited capacity for analysis and expertise – The need for additional expertise on local level.
- ✓ Lack of coordination between institutions – There are still difficulties in the exchange of information between different state and local institutions, which slows down the decision-making process, as well as data exchange.
- ✓ In order to achieve more effective climate risk management in the next phases of the project, the following measures are needed:
- ✓ Additional data collection – Expanding the local data base through sensor networks, historical analyses and remote sensing.
- ✓ Expanding the analysis – Using advanced climate models and forecasting tools to improve the accuracy of predictions.
- ✓ Raising awareness and engagement – Conducting additional meetings and consultations with stakeholders, including sectors such as agriculture, transport and energy and representatives of civil society.

Phase 1 of the Climate Risk Assessment for the Municipality of Silistra provided a valuable basis for the further stages of the CLIMAAX project. It provided a clearer picture of the climate risks in the region, engaged key stakeholders and identified the main gaps in the available data and resources.

3 Progress evaluation and contribution to future phases

Following the successful initial phase where the CLIMAAX methodology and toolbox were tested using the river flood and heavy rainfall hazards, the project *"Towards Climate Resilience: Assessing Silistra's Climate Challenges and Solutions"* will now enter a more comprehensive stage over the next 16 months. The current Deliverable Report concludes Phase 1 and its outputs serve as the essential foundation for the activities planned in the subsequent phases detailed in the project. The Phase 1 includes the initial testing and validation of the CLIMAAX methodology and toolbox within the specific context of Silistra. By focusing on two key hazards – River Floods and Heavy Rainfall – this phase demonstrated the methodology's applicability and generated preliminary risk insights for these specific threats. The report's outputs are therefore the validated workflows and initial risk assessment results specifically for river floods and heavy rainfall.

The core focus of these upcoming steps will be to conduct the full Multi-Risk Climate Assessment for Silistra. This involves applying the validated methodology to analyze all other relevant climate hazards (such as drought, wind and snow) that impact the municipality, building upon the insights gained from the initial flood and rainfall analysis. This comprehensive assessment will involve further data collection and detailed analysis to create a complete picture of Silistra's climate vulnerabilities.

Based on the findings of this complete assessment, subsequent key activities will include:

- ✓ Integrating findings into local policy: The results will directly inform the review and updating of crucial municipal strategic and planning documents, ensuring that climate resilience is embedded in local governance, particularly within instruments like the disaster risk reduction program.
- ✓ Engaging stakeholders: Workshops are planned to discuss both the methodology's application and, later, the results of the full multi-risk assessment. This will ensure continued collaboration and input from local and national stakeholders.
- ✓ Developing adaptation strategies: The comprehensive understanding of risks across all hazards will enable the identification and development of targeted, actionable adaptation strategies suitable for Silistra's specific context.
- ✓ Disseminating results: Project findings and recommendations will be shared through ongoing communication efforts, culminating in a final conference towards the end of the 22-month period to ensure broad awareness and uptake of the results.

Essentially, the project will move from methodology testing to full-scale implementation, aiming to provide Silistra with a robust, evidence-based foundation for enhancing its long-term climate resilience.

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
1 climate multi-risk assessment report published (month 6 and Month 16)	Deliverable 1 submitted on 31 March 2025
10000 residents, key local and regional authorities, and stakeholders	Pending

Key performance indicators	*Progress*
reached through awareness campaigns (Month 22)	
2 workshops, one final conference and meetings conducted for decision-makers (Months 2, 6, 15, 22)	Organized and conducted kick-off meeting with the project team, municipal stakeholders and external expert. On 28 March 2025 was held workshop aimed at educating stakeholders on the practical application of the CLIMAAX Common Methodology Framework.
Municipal strategic documents on disaster management and environmental management reviewed and revised (Month 21)	Pending
At least 1 risk management measure integrated into local development planning (Month 21)	Pending
Preparing outline for a long-term climate resilience strategy (Month 21)	Pending
1 media/press conference (Month 2)	On 24 October 2024 was organized a press-conference to inform key stakeholders, media, and the public with information about the framework's objectives, significance, and expected outcomes
5 publications on the website of the municipality for the project (Months 2, 6, 16, 21, 22)	1 press release was published on the website for the workshop aimed at educating stakeholders on the practical application of the CLIMAAX Common Methodology Framework.
2 communication actions taken to share results with stakeholders – 1 workshop and 1 final conference (Months 15, 22).	Pending

Table 4-2 Overview milestones

Milestones	*Progress*
M1: Completion of the review of local legal, financial, and administrative frameworks with recommendations for improvement (Month 5)	Review of local legal, financial, and administrative frameworks with recommendations for improvement completed on 14 March 2025

Milestones	*Progress*
M2: Kick-off meeting of the project team with municipal and external experts (Month 2)	Organized and conducted kick-off meeting with the project team, municipal stakeholders and external expert.
M3: Press conference to announce the project and its goals (Month 2)	On 24 October 2024 was organized a press-conference to inform key stakeholders, media, and the public with information about the framework's objectives, significance, and expected outcomes
M4: Completion of the workshop on the application and adaptation of the CLIMAAX framework (Month 6)	On 28 March 2025 was held workshop aimed at educating stakeholders on the practical application of the CLIMAAX Common Methodology Framework.
M5: Submission and acceptance of the report on the application and adaptation of the CLIMAAX framework (Month 6)	On 31 March 2025 the Report on the application and adaptation of the CLIMAAX framework has been submitted (Deliverable 1 (M6))
M6: Attend the CLIMAAX workshop held in Barcelona (Month 10)	Pending
M7: Completion of the desktop research on municipal, regional, and national data related to climate risks and vulnerable sectors (Month 14)	Pending
M8: Workshop with local and national stakeholders to gather additional data and insights (Month 15)	Pending
M9: Submission and acceptance of the report on multi-risk assessment results (Month 16)	Pending
M10: Completion of the review and revision of the municipal disaster risk reduction program based on multi-risk and vulnerabilities identified (Month 19)	Pending
M11: Amendments to the Ordinance on Disaster and Accidents Management and municipal strategic documents (Month 21)	Pending
M12: Attend the CLIMAAX workshop held in Brussels (December 2026)	Pending
M13: Final conference on project results to disseminate findings and recommendations (Month 22)	Pending

Supporting documentation

1. Main report (*.PDF format)
2. Generated output from River Floods workflow (*.ZIP archive)
3. Generated output from Heavy Rainfall workflow (*.ZIP archive)
4. Report on the Review and analysis of the legal, financial and administrative framework for managing climate change risks in the Municipality of Silistra (Subcontracted Activity 1 under the project) (*.PDF format)
5. Publicity about the project

https://silistra.egov.bg/wps/portal/municipality-silistra/administration/projects/pokana-seminar
https://silistra.egov.bg/wps/portal/municipality-silistra/actual/news/seminar-klimaks
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4 References

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IME: Regional Profiles 2024. *https://www.regionalprofiles.bg/var/docs/2024_BG/19-Silistra-2024-BG.pdf* 2024