Deliverable Phase 1 – Climate risk assessment

Climate Resilience and Risk Management Approach to Flood and Erosion through Data-Driven Adaptation Response in Libohova (CLEAR-AL)

Albania, Libohova Municipality

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Project name	Climate Resilience and Risk Management Approach to Flood and Erosion through Data-Driven Adaptation Response in Libohova (CLEAR-AL)
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Abbreviations and acronyms

Abbreviation / acronym	Description
CLEAR-AL	**C**limate Resilience and Risk Management Approach to Flood and Erosion through Data-Driven Adaptation Response in Libohova
CLIMAAX	**CLIMA**te risk and vulnerability **A**ssessment framework and toolbo**X**
RCP	Representative Concentration Pathways
GIS	Geographical Information System
ERA5	Fifth generation ECMWF atmospheric reanalysis of the global climate
INSTAT	**In**stitute for **stati**stics
AMBU	Agency for water Resources Management
IGJEO	Institute of Geosciences
RAPA	Regional Administration of Protected Areas
NGO	Non-governmental organization
INCA	Institute for Nature Conservation in Albania
CRA	Climate Risk Assessment
PVNK/LCAP	Local Climate Change Plan
UNDP	United Nation Development Programme
LCCP	Local Climate Change Plan
ND-GAIN	The Notre Dame Global Adaptation Initiative
EM-DAT	The Emergency Events Database
UNFCCC	United Nations Framework Convention on Climate Change
MFZ	Mediterranean Field Zone
MHZ	Mediterranean Hilly Zone
MPMZ	Mediterranean Pre-Mountain Zone
MMZ	Mediterranean Mountainous Zone
RCP	Representative Concentration Pathways
RP	Return period

Executive summary

This deliverable outlines the outcomes of Phase 1 of the CLEAR-AL project, carried out under the CLIMAAX program, with a focus on developing a comprehensive climate risk assessment for Libohova Municipality in Albania. The assessment responds to the increasing demand for structured, evidence-based climate adaptation planning at the local level, particularly in rural areas with limited institutional capacity and high exposure to climate hazards.

The report applies the CLIMAAX methodology to identify and examine four priority climate hazards: heavy rainfall, flooding and related damages, population exposure to floods, and drought. The analysis draws on historical records, stakeholder contributions, and scenario-based projections. Each hazard was evaluated through tailored workflows that combined hazard intensity, geographic exposure, and social vulnerability.

Key activities during this phase included the creation of a municipal implementation team, the signing of a cooperation agreement with the Media, Education, Environment & Technology Centre (MEET Centre), and the successful completion of stakeholder consultations. These steps ensured inclusive participation and reinforced local ownership of the risk assessment process. Visual tools such as risk maps and vulnerability profiles were produced to support decision-making and guide future planning.

The deliverable also highlights critical capacity gaps in data availability, technical expertise, and early warning systems. It proposes a structured work plan for the next phases, including validation of risk outputs, prioritization of adaptation measures, and integration into municipal planning frameworks. The findings directly contribute to the broader objectives of the CLIMAAX program by aligning local adaptation efforts with European climate governance standards.

In summary, this phase has established a solid analytical foundation for climate resilience in Libohova Municipality. It underscores the urgency of targeted interventions, the benefits of participatory approaches, and the importance of sustained capacity-building to effectively address climate risks. The outputs of this deliverable will inform future adaptation strategies and support the municipality’s transition toward climate-smart and inclusive development.

1 Introduction

1.1 Background

Libohova is located in southern Albania within Gjirokastër County, bordered by Këlcyrë to the north, Përmet to the east, Dropull to the south, and Gjirokastër to the west. The municipal centre is the town of Libohova. Covering an area of 248 km², the municipality has a population of 2,765 according to the 2023 Census, while the Civil Registry records 7,158 inhabitants, resulting in a low population density of about 29 people per km². Administratively, Libohova consists of three units: Libohovë, Qendër Libohovë, and Zagorie, comprising one town and seventeen villages.

Figure 1.1-1 Map of Libohova Municipality

Historically, Libohova has held administrative importance since 1914 as a sub-prefecture. The area is distinguished by its archaeological sites, cultural monuments, religious landmarks, and natural attractions, many of which are internationally recognized and accessible year-round. Despite low demographic growth over the past two decades, migration has declined, and the municipality shows potential for employment, investment, and tourism development.

The local economy is primarily based on agriculture, livestock farming, and natural resource use. Libohova is notable for its extensive agricultural land and record diversity of medicinal plants in Albania. Sheep and goat farming play a central role in livelihoods, while forestry and water resources support farming and grazing. Tourism is emerging as a promising sector, driven by cultural heritage, eco-tourism, and cross-border cooperation projects, including IPA initiatives with neighbouring regions such as Zagorie and Greece.

However, these economic activities face increasing risks from climate change. Agriculture and medicinal plant cultivation are vulnerable to droughts, which reduce yields and biodiversity. Livestock farming is threatened by heatwaves and water scarcity, affecting pasture quality and animal health. Heavy rainfall and floods pose risks to infrastructure, farmland, and ecosystems, while tourism may suffer from reduced accessibility and damage to natural and cultural sites. These vulnerabilities highlight the need for targeted investments in infrastructure, sustainable agriculture, livestock management, and climate-resilient tourism.

Libohova's geographic position, rich resources, and active participation in cross-border projects make it a potential hub for regional development. Strengthening infrastructure, enhancing early warning systems, and investing in sustainable practices will be essential for safeguarding its economy and supporting a transition toward climate-smart, inclusive growth.

Although institutional capacity remains limited, Libohova demonstrates growing commitment to climate adaptation and environmental governance. Community engagement is strong, with active participation from youth and women's groups. These dynamics position Libohova as a strategic pilot site for the CLEAR-AL project, offering both challenges and opportunities for building climate resilience under the CLIMAAX program.

1.2 Main objectives of the project

The CLEAR-AL project represents a strategic effort to strengthen Libohova Municipality's resilience to climate change by applying the CLIMAAX Handbook within the local context. Its overarching goal is to assess climate risks and design adaptive strategies that safeguard critical sectors—agriculture, infrastructure, tourism, and public health—against hazards such as floods, heavy rainfall, erosion, and other extreme weather events. By embedding European methodologies into local planning, the project enhances evidence-based decision-making, builds institutional capacity, and promotes inclusive, community-driven responses to climate challenges.

CLEAR-AL is structured to deliver a robust, locally tailored adaptation framework. Its specific objectives include:

- conducting a **comprehensive multi-hazard risk assessment** to identify vulnerabilities unique to Libohova;
- **integrating high-resolution local data and stakeholder** insights to refine risk profiles;
- **developing actionable adaptation measures** and improved risk management plans with targeted interventions in agriculture, urban development, and tourism; and
- **strengthening institutional capacity** while fostering broad stakeholder ownership to ensure sustainability.

Beyond identifying risks, the project emphasizes co-creation of solutions. It combines scientific expertise, detailed local datasets, and the lived experiences of residents to design practical strategies that protect farms, towns, and cultural assets while safeguarding community wellbeing. By involving local voices and institutions at every stage, CLEAR-AL ensures that adaptation plans are technically sound yet deeply rooted in Libohova's realities. This participatory approach builds trust, empowers local leaders, and embeds climate resilience into municipal governance.

Thanks to the CLIMAAX Handbook, Libohova now has a clear roadmap for managing climate risks. The project provides better tools for decision-making, fosters stronger partnerships, and lays the foundation for a more resilient and inclusive future for all residents.

1.3 Project team

After signing the agreement with the CLIMMAX program, the Municipality of Libohova approved through the Decision of the Municipal Council dated 04.08.2025 (No. Ref. 1412) the engagement of the municipal staff and decided to officially establish a team dedicated to leading the implementation of the CLEAR-AL project. The team was established through the Order of the Mayor No. 228, dated 04.02.2025. This internal working group is composed of municipal specialists from the departments of urban planning, legal affairs, public procurement and IT, each of whom has been assigned specific responsibilities to support the implementation of the project.

To strengthen the technical capacity, the Municipality procured and established a cooperation agreement with the Media, Education, Environment & Technology Centre (MEET Centre), acting as a subcontractor. MEET mobilized a multidisciplinary team of experts, including:

- **Climate Adaptation Specialist**, responsible for assessing climate risks and identifying priority adaptation measures;
- **GIS and Cartography Expert**, leading spatial analysis and developing thematic risk and vulnerability maps to support decision-making;
- **Hydrologist**, providing expertise on water-related risks and hydrological modelling;
- **Institutional and Legal Advisor**, ensuring compliance with national legislation and supporting governance frameworks in line with international frameworks.

Together, this integrated team is leading the development of the Climate Adaptation Plan of the Municipality of Libohova, combining local knowledge with scientific analysis to build a resilient future for the municipality.

1.4 Outline of the document’s structure

This Climate Adaptation Action Plan for the Municipality of Libohova provides a clear, evidence-based framework for understanding local climate risks and identifying priority measures for resilience. The document begins with a summary of the current socio-economic context of Libohova, highlighting demographic trends, economic activities, and environmental characteristics that shape the municipality’s vulnerability to climate change.

The plan is aligned with the CLEAR-AL project implementation under the CLIMAAX program, with a focus on Phase 1: Climate Risk Assessment. It follows a logical progression from contextual framing to technical analysis and forward-looking planning.

Report Structure

Executive Summary – Concise synthesis of project objectives, activities, and key findings.

Section 1 – Introduction – Background of Libohova Municipality, objectives of the CLEAR-AL initiative, project team composition, and structural outline.

Section 2 – Climate Risk Assessment (Phase 1) – Core of the report, divided into six subsections:

- Scoping – Objectives, local context, and stakeholder engagement approach.
- Risk Exploration – Hazard selection, methodological workflows, and scenario development.
- Risk Analysis – Application of workflows to assess vulnerabilities and exposure.
- Preliminary Key Risk Assessment Findings – Summary of severity, urgency, and adaptive capacity.
- Monitoring and Evaluation – Initial indicators and approaches for tracking progress.
- Work Plan – Next steps and implementation priorities.

Section 3 – Conclusions – Synthesis of Phase 1 insights and implications.

Section 4 – Progress Evaluation and Future Contributions – Assessment of current status and alignment with subsequent CLIMAAX phases.

Section 5 – Supporting Documentation – Annexes, visuals, and technical materials produced during the project.

Section 6 – References – Sources, methodologies, and tools consulted throughout the process.

This structure ensures clarity, traceability, and alignment with the CLIMAAX Handbook, facilitating both local ownership and replicability across other municipalities.

2 Climate risk assessment – phase 1

This section presents the first phase of the climate risk assessment for Libohova Municipality, structured according to the analytical steps of the CLIMAAX Framework. The process follows a systematic sequence: Scoping, Risk Exploration, Risk Analysis, and Preliminary Assessment, guided by the key questions outlined in the CLIMAAX Handbook. These questions provide the backbone of the analysis, ensuring consistency and methodological rigor. In cases where data or information was insufficient to fully address a guiding question, this has been explicitly noted to maintain transparency and highlight areas requiring further investigation.

2.1 Scoping

The scoping phase of the climate risk assessment establishes the analytical foundation for the CLEAR-AL project in Libohova. Its primary objectives are to identify climate-related hazards, assess local vulnerabilities, and provide evidence-based insights that inform adaptation strategies designed to strengthen resilience across key sectors. This phase also sets out the contextual conditions in which the project operates, including the municipality's geographic, socio-economic, and institutional characteristics.

Libohova's rural economy relies heavily on agriculture, livestock, and natural resources, yet these sectors are increasingly exposed to climate stress. Droughts, soil erosion, and seasonal variability are becoming more pronounced, while floods and heavy rainfall events pose growing risks to infrastructure and livelihoods. These pressures are compounded by limited access to localized climate data, constrained institutional capacity, and the absence of integrated planning tools that could guide long-term adaptation.

Climate change represents a profound shift in long-term patterns of temperature, precipitation, and extreme weather, with serious consequences for ecosystems, communities, and rural systems. While natural variability has always existed, scientific consensus links the acceleration of global warming to human activities such as fossil fuel use, intensive agriculture, and unregulated urban expansion. For Libohova, these changes translate into heightened risks of floods, droughts, landslides, and erosion, with cascading impacts on agriculture, tourism, and public health.

Unlike larger urban centres that have begun to adopt structured climate planning instruments, Libohova has yet to establish a formal framework for adaptation. The National Adaptation Plan provides a model for integrating mitigation and adaptation into local governance, offering smaller municipalities a pathway to strengthen resilience while pursuing inclusive, green development. CLEAR-AL seeks to replicate this strategic approach in Libohova, tailoring it to the municipality's rural context and specific capacities.

The scoping phase also identifies the stakeholders whose engagement is essential throughout the project. These include municipal authorities, farmers, local businesses, youth and women's groups, environmental NGOs, and technical experts. Their participation ensures that the risk assessment reflects local realities, builds ownership, and supports inclusive decision-making. Stakeholder involvement is not only critical for data collection and validation but also for co-designing adaptation measures that are practical, equitable, and sustainable.

2.1.1 Objectives

The main objective of the Libohova Climate Risk Assessment (CRAA) Phase 1 is to create a clear understanding of the tools, datasets and workflows applied through the CLIMAAX methodology. This initial phase focuses on assessing the main hazards and risks, in particular flood-related building damage, population exposure, droughts and extreme rainfall, and examining how climate change may intensify river flood risks and rainfall variability in the municipality.

The expected outcome of Phase 1 is a comprehensive baseline assessment of these hazards and risks, with particular attention to urban areas that are highly vulnerable to flooding during extreme rainfall events and agricultural areas affected by intense rainfall and droughts. This baseline will serve as the basis for Phase 2, where the analysis will be refined through the integration of high-resolution local datasets, historical data, and empirical methods. Phase 2 will also expand the scope to identify additional sectors and hotspots facing high levels of climate risk, hazard, and impact.

Together, the results of Phases 1 and 2 will inform the design of targeted adaptation measures and contribute to the update of the local climate adaptation framework of Libohova, in line with the National Adaptation Plan. These measures will strengthen the resilience of municipalities by addressing vulnerabilities in infrastructure, agriculture, and community systems.

The main limitations identified in Phase 1 relate to data availability and resolution. Key gaps include building footprints and typologies, transport infrastructure layers, socio-economic development scenarios, hydrological discharge values for current and future climate conditions, and high-resolution flood maps for future scenarios. Addressing these gaps in Phase 2, through advanced modelling, stakeholder consultations, and integration of localized datasets, will enable the production of updated hazard and risk maps that enhance local understanding of climate hazards.

To achieve these objectives, several adaptation interventions are envisaged:

- upgrading and modernizing infrastructure to reduce flood risk;
- promoting nature-based solutions, such as watershed afforestation, stream restoration, and water retention measures; and
- mitigating urban flood risks through spatial planning that includes rainwater collection and storage systems.

2.1.2 Context

Albania is vulnerable to a range of natural disasters. The main hazards affecting Albania are earthquakes, floods, forest fires and landslides. Other hazards include snowstorms, droughts, temperature extremes, epidemics, avalanches and windstorms. The International Disaster Database (EM-DAT) shows that, during 1979-2019[1], floods accounted for the majority of disaster events (38%), followed by earthquakes (15%). The vulnerability of the Albanian population to disasters of large and small scales is compounded by poverty, poor quality infrastructure and communications, a construction boom and a range of human-influenced environmental factors, from rapid deforestation and poor watershed management to environmental pollution. Moreover, the education and awareness of the population on these risks remains low.

[1] https://www.emdat.be/categories/report/

Recent data highlights that Albania has become increasingly vulnerable to disasters, as nearly all major climate hazards have escalated into large-scale emergencies over the past decade. Numerous reports confirm the country's high exposure and susceptibility to risks, coupled with limited institutional capacity to effectively cope with and adapt to them. Climate change further intensifies these vulnerabilities. Extreme rainfall frequently triggers destructive floods, while prolonged dry spells threaten agricultural productivity and drinking water supplies. Rising temperatures are expected to magnify both wet and dry extremes, alongside an overall decline in annual precipitation. These dynamics place communities, hydropower systems, and tourism at significant risk. Albania's socio-economic development trajectory compounds this exposure. The ND-GAIN Index in 2021 ranked the country 80th out of 182 globally, with vulnerability at 78th and readiness at 96th. National Communications to the UNFCCC reaffirm that Albania's climate vulnerability remains high, underscoring the urgent need for strengthened adaptation and resilience measures.

To address these challenges, Albania has adopted a series of governance frameworks, including the National Climate Change Strategy (2019–2030)[2], the Climate Change Law (2020)[3], the Nationally Determined Contribution (2021)[4], and the Fourth National Communication (2022)[5]. The country launched the Albania's Second National Adaptation Plan (2026–2036)[6] which sets a long-term vision to strengthen climate resilience against heatwaves, droughts, floods, storms, and sea-level rise that threaten communities, infrastructure, and ecosystems. Developed through a country-driven, inclusive process (2021–2025) with national institutions and eight municipalities, and supported by UNDP and the Green Climate Fund, the plan includes 66 priority measures across agriculture & forestry, energy, transport, urban development, and tourism, supported by cross-sector actions on governance, data, and finance. Despite these commitments, implementation remains constrained by limited financial resources, technical capacity, and reliance on donor support.

At the local level, the Municipality of Libohova demonstrates the urgent need for a structured climate risk assessment. Historically, risks such as droughts, floods, fires and erosion have been addressed through fragmented and reactive measures. Communities have relied on traditional agricultural practices to cope with seasonal variability, but no formal or systematic climate risk assessment has been undertaken. This lack of structured planning has limited the municipality's ability to anticipate and mitigate the increasing impacts of climate change.

In recent years, Libohova has faced increasing exposure to climate-related threats due to changing precipitation patterns, rising temperatures and land-use changes. These pressures have impacted agriculture, water resources and rural infrastructure. However, the lack of local climate data, limited technical expertise and lack of integrated planning tools have hindered proactive risk management and the development of long-term sustainability.

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[2] https://mjedisi.gov.al/wp-content/uploads/2021/10/2.-Strategjia-e-Ndryshimeve-Klimatike-dhe-Planet-e-Veprimit_Qershor-2019_-1.pdf
[3] https://mjedisi.gov.al/wp-content/uploads/2021/10/1.-Ligji-nr.-155-dt.-17.12.2020_PER-NDRYSHIMET-KLIMATIKE-1.pdf
[4] https://mjedisi.gov.al/wp-content/uploads/2021/10/3.-Kontributi-Komb%C3%ABtar-i-Percaktuar-KKP-i-rishikuar-p%C3%ABr-Shqip%C3%ABrin%C3%AB-1.pdf
[5] https://www.undp.org/albania/publications/fourth-national-communication-albania-climate-change
[6] https://www.undp.org/albania/publications/albanias-national-adaptation-plan-2026-2036

The CLEAR-AL project addresses this gap by introducing the first structured climate risk assessment for Libohova, guided by the CLIMAAX Framework. Its objective is to institutionalize climate adaptation planning, enabling the municipality to comply with national and European climate resilience objectives. The project responds to a fundamental challenge: the lack of integrated climate governance at the local level, which leaves key sectors vulnerable and undermines sustainable development efforts. Libohova operates within a governance context shaped by Albania's national climate strategies and EU-harmonized environmental policies. However, municipal institutions continue to face limitations in technical expertise, financial resources and access to relevant climate data, delaying the integration of risk considerations into local decision-making. Several sectors are particularly vulnerable to climate variability, including agriculture, livestock, tourism, infrastructure and public health. Droughts threaten crop yields and water availability; floods and erosion damage roads and buildings; and heat waves pose risks to vulnerable populations. Without targeted adaptation measures, these sectors will remain exposed to increasing challenges.

External initiatives, such as regional programs for biodiversity conservation, water resource management, and rural revitalization, offer opportunities for synergy and knowledge exchange. These efforts can complement CLEAR-AL by providing technical inputs, policy alignment, and community engagement models, thereby strengthening Libohova's ability to adapt and thrive in the face of climate change.

2.1.3 Participation and risk ownership

To effectively address climate and environmental challenges in Libohova, it is essential to understand the institutional, legal, and planning framework that underpins local action. This framework reflects the interaction between municipal and central actors, legal instruments, and strategic plans, which together form the foundation of climate governance. This section examines the institutional roles, competences, and interactions, as well as the alignment of existing policies with climate adaptation needs, highlighting opportunities for stronger cross-sectoral integration and improved local capacities.

The stakeholder engagement process for CLEAR-AL began with a mapping of relevant actors across local government, civil society, and technical fields. Initial consultations were held with municipal authorities, community representatives, and environmental experts to identify key stakeholders and define their roles in the climate risk assessment. The MEET Centre, as implementing partner, facilitated this process by coordinating outreach activities and ensuring inclusive participation.

Key stakeholders include:

- **Local Government**: Libohova Municipality, administrative units, and planning departments.
- **Regional Institutions**: Gjirokastër Prefecture (civil emergencies directorate), regional environmental office, regional administration of protected areas, and the Vjosa River Basin Council.
- **Civil Society**: Local NGOs, youth and women's groups, farmers' and livestock associations, beekeepers, medicinal plant collectors, guesthouses, and agribusinesses.
- **Private Sector**: Tourism operators, small businesses, hotels, credit associations, restaurants, and tourist guides.

- **Academia and Experts**: University of Gjirokastër – Faculty of Natural Sciences, biodiversity specialists, climate researchers, and technical consultants (urban planners, hydrologists, agricultural and natural resource managers, socio-economic experts).
- **Citizens**: Residents of vulnerable areas, particularly those in flood-prone or resource-dependent communities.

An organogram (fig.2.1.3-1) has been developed to visualize institutional relationships, responsibilities, and communication flows. This tool supports coordination and clarifies how stakeholders contribute to risk identification, data collection, and decision-making.

Figure 2.1-1 Organogram of key actors and their connection

Priority groups include smallholder farmers, pastoralists, older people, and women in rural areas—communities disproportionately exposed to climate risks and often lacking adaptive resources. Their inclusion ensures that the assessment reflects lived realities and promotes equitable resilience planning.

Risk ownership is primarily regulated through the municipal government, which is responsible for integrating climate risk into local development plans and emergency response systems. INCA provides technical support, while community stakeholders contribute local knowledge and monitoring capacity. This shared ownership model fosters accountability and sustainability.

The acceptable level of risk for the community is low, particularly regarding threats to livelihoods, water security, and public health. Residents express growing concern about climate variability and support proactive measures to reduce vulnerability.

Project results will be communicated through multiple channels:

- Local dissemination via public meetings, visual materials, and community workshops.
- Institutional reporting to municipal and regional authorities.
- Technical documentation for national agencies and CLIMAAX partners.
- Public outreach through media, social platforms, and educational campaigns.

This multi-level communication strategy ensures transparency, builds trust, and supports the integration of findings into broader climate governance frameworks.

2.2 Risk Exploration

Risk exploration represents the starting point of the climate risk assessment for Libohova Municipality. This step requires the systematic identification of climate-related risks, exposures, and vulnerabilities specific to the local context. To ensure that the assessment captures the most pressing threats, the process must actively engage key stakeholders and incorporate community concerns.

The outcomes of risk exploration should establish a clear foundation for subsequent phases of analysis, providing the evidence base needed to design targeted and effective adaptation measures.

2.2.1 Screen risks (selection of main hazards)

Figure 2.2-1 The main climatic regions in Albania (Source: SUPPORT TO FILLING GAPS IN Climate Change Adaptation. Data and Risk Analysis. Government of Albania

According to the Köppen climatic classification, Albania is characterized by a Mediterranean climate, with mild and humid winters followed by hot and dry summers. Due to the country's diverse topography, significant climatic variations occur within this general pattern. Northern, north-eastern, and south-eastern regions experience very cold winters, while the coastal areas are marked by extremely hot and dry summers.

Taking into account spatial differences in temperature and precipitation regimes, Albanian climatologists divide the national territory into four major climatic zones (Figure 2.2-1): Mediterranean Field Zone (MFZ), Mediterranean Hilly Zone (MHZ), Mediterranean Pre-Mountain Zone (MPMZ), and Mediterranean Mountainous Zone (MMZ), further subdivided into 13 subzones.

Temperature trends across Albania reveal a clear upward trajectory, particularly evident in the last two decades. This increase, illustrated in Figure 2.2-2, underscores the growing influence of climate change on national climatic conditions.

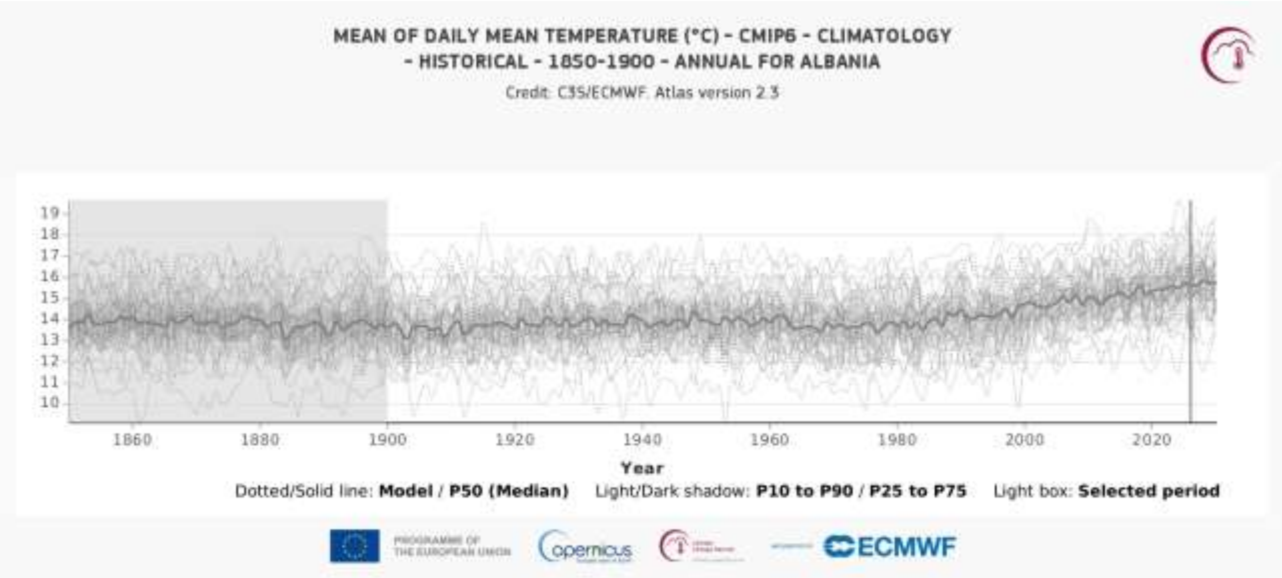

Figure 2.2-2 Mean of daily mean temperature-Annual for Albania

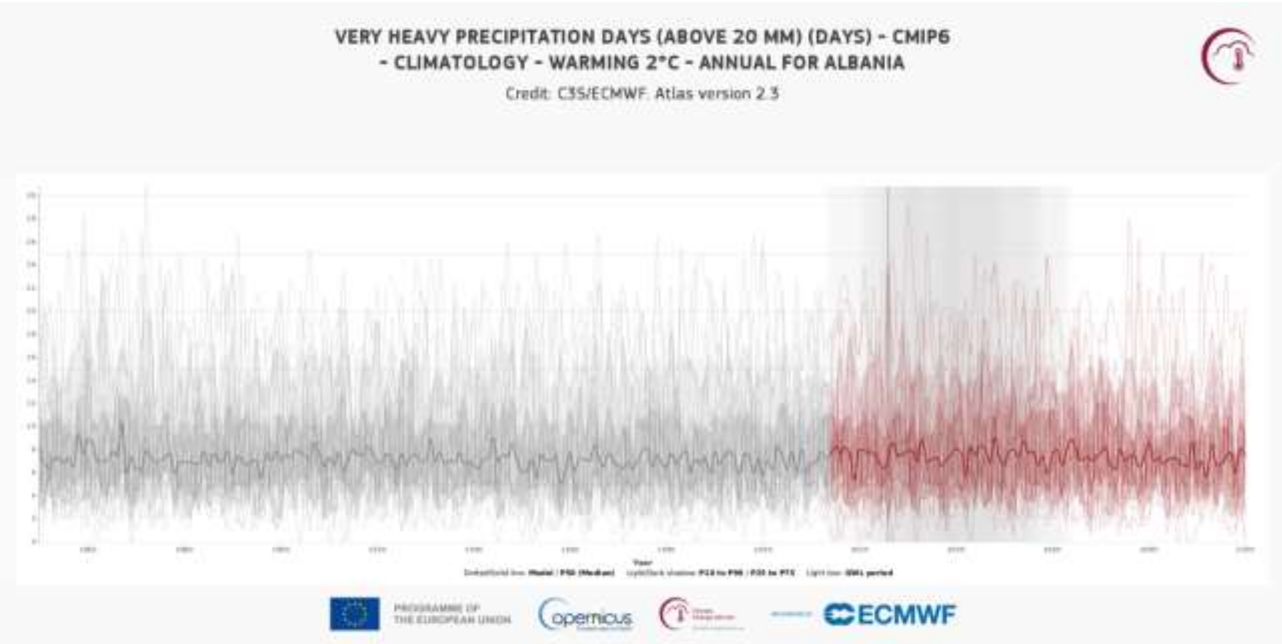

Figure 2.2-3 Very heavy precipitation days - annual for Albania

The Copernicus Climate Atlas (Figure 2.2-3) shows that Albania has experienced increasing variability in rainfall over recent decades, with extreme precipitation events becoming more frequent. Under high-emission scenarios, projections indicate that rainfall intensity during extreme events will continue to rise, while total annual precipitation is expected to decline. This dual trend, less overall rainfall but more intense downpours, creates heightened risks of both droughts and floods. For Libohova Municipality, this means agricultural areas and rural households will face greater exposure to water stress and flood damage, underscoring the need for improved hydrological forecasting, localized flood mapping, and climate-resilient infrastructure.

Local communities in Libohova, particularly those near riverine and stream systems and flood-prone zones, already identify flooding and heavy rainfall as major risk factors for flash floods. These hazards were prioritized for analysis within the scope of the CLEAR-AL project. The risks associated with them include loss of life, damage to property, disruption of livelihoods, and interruptions to essential services. Through stakeholder consultations and initial environmental evaluations, a detailed assessment of climate-related hazards was carried out, confirming river/stream flooding and extreme rainfall as the most pressing climate risks affecting Libohova.

Libohova Municipality is already experiencing tangible impacts from climate-related hazards, with several areas and vulnerable population groups facing recurring challenges. The current situation reveals a growing pattern of exposure and vulnerability across both natural and socio-economic systems, highlighting the urgency of structured climate risk assessment and targeted adaptation planning.

Seasonal floods, soil erosion, and extreme rainfall events have become increasingly frequent, placing pressure on agriculture, infrastructure, and household economies. Local streams represent critical hotspots of risk, where recurring hazards directly affect communities and livelihoods.

The **Baillo Stream** regularly overflows between November and February, threatening the Baillo neighbourhood and damaging roads, bridges, and private properties. The **Zhepe Stream** floods agricultural land, reducing productivity, eroding soils, and undermining family incomes. The **Panos/Çuprel Stream**, divided into upper and lower sections, has deepened significantly, increasing erosion risks. Landslides have already damaged the Çuprel neighbourhood road, while nearby homes face growing danger from terrain instability. The Çuprel area is considered one of the most critical zones, requiring urgent intervention.

Key findings from local observations and stakeholder consultations confirm:

- A rising frequency of seasonal floods.
- Accelerated degradation of agricultural land.
- Increased risks to infrastructure and residential areas.
- Direct impacts on livelihoods and the local economy.

These challenges underscore the need for improved hydrological forecasting, localized flood mapping, and climate-resilient infrastructure. Addressing vulnerabilities linked to Libohova’s streams is essential to safeguard communities, protect agricultural production, and strengthen long-term resilience against climate change.

2.2.2 Workflow selection

Given that river flooding and heavy rainfall were identified as the primary hazards for analysis in the project, the risk workflows relevant to the Climate Risk Assessment (CRA) for Libohova Municipality include River Flooding, Flood Damage and Population Exposure, and Droughts. While the initial work plan referred only to the two main workflows: River Flooding and Extreme Precipitation, it was considered valuable to also integrate the Building and Population Exposure and Droughts workflow.

This addition is directly connected to the river flooding workflow, as it relies on the same underlying hazard. In the context of Libohova, situated within the Drino River basin, the presence of several small streams prone to overflow during intense rainfall events makes the inclusion of exposure analysis particularly important. By linking hazard data with population and infrastructure exposure, the CRA provides a more comprehensive understanding of flood risk and its potential impacts on the municipality

2.2.2.1 Workflow #1- Extreme precipitation

This workflow focuses on areas within Libohova Municipality that are regularly affected by intense and prolonged rainfall, a hazard that is becoming more frequent due to climate change. The most vulnerable zones include rural settlements located on steep slopes, poorly drained urban corridors, and road infrastructure connecting the town centre with surrounding villages. Critical hotspots such as central transport routes, hillside housing clusters, and inadequately designed stormwater systems face heightened risks of surface runoff, landslides, and flash flooding triggered by heavy rainfall.

Regional analyses indicate that most landslides in hilly terrain are directly caused by extreme precipitation events (National Disaster Risk Reduction Strategy, pp. 22–24). Although typically localized and sudden, these events often result in severe damage and disrupt access roads and essential infrastructure due to the steep topography and the proximity of settlements to streams and slopes. In Libohova, soil saturation in hillside settlements frequently leads to small-scale landslides, directly impacting homes and living spaces.

The populations most at risk include residents in structurally unsafe hillside housing, rural households along landslide-prone slopes, and commuters dependent on vulnerable transport networks. Socio-economically disadvantaged groups—particularly women, the elderly, and low-income families—face heightened vulnerability due to limited adaptive capacity, restricted mobility, and inadequate access to early warning systems. Agricultural and seasonal workers are also heavily affected, as extreme rainfall disrupts access to farmland, damages crops, and interrupts work cycles essential to livelihoods.

2.2.2.2 Workflow #2 – River flooding

Seasonal floods triggered by intense rainfall represent a recurring hazard for Libohova Municipality, particularly in areas where settlements are located close to streams and low-lying zones within the Drino River basin. Households situated along flood-prone corridors and elderly residents are among the most vulnerable groups, facing risks such as damage to infrastructure, contamination of water supplies, and disruption of mobility.

The absence of detailed floodplain mapping and the limited availability of drainage system data continue to hinder effective planning and preparedness. As a result, communities in Libohova lack the necessary tools to anticipate and mitigate the impacts of floods, leaving them exposed to recurring hazards that are expected to intensify under future climate conditions.

2.2.2.3 Workflow #3 - Flood building damages and population exposed

In cases of flood damage to buildings and risks affecting the population, the most vulnerable groups and exposed areas in Libohova Municipality are primarily those located within urban zones and the surrounding communities. In regions experiencing tourism development, particularly in hilly and sub-mountainous areas and resorts situated along rivers and streams, risk levels rise significantly during the tourist season due to increased population density.

The growing frequency and intensity of heavy rainfall events pose a serious hazard for Libohova, especially affecting agricultural zones in lowland fields and river-adjacent farmlands. Vulnerable groups such as smallholder farmers, livestock keepers, rural women, and seasonal agricultural workers face mounting risks, as flooding and waterlogging reduce crop yields, erode soils, damage pastures, and compromise rural infrastructure.

By linking hazard analysis with exposure and vulnerability, the assessment highlights how Libohova's hydrological conditions, demographic shifts, and economic activities combine to intensify flood-related risks for both urban and rural populations.

2.2.2.4 Workflow #3 – Droughts

The agricultural drought workflow evaluates the impacts of precipitation deficits and soil moisture anomalies on farming systems and rural livelihoods. In Libohova Municipality, drought conditions are expected to intensify due to climate change, directly affecting key sectors such as crop production, livestock rearing, and small-scale forestry.

Vulnerable areas include rainfed agricultural zones, lowland fields adjacent to streams, and lands with limited irrigation infrastructure, where prolonged dry periods reduce water availability and soil productivity. Communities most exposed are smallholder farmers, livestock keepers, rural women, and seasonal agricultural workers, who depend heavily on rain-fed agriculture and have limited adaptive capacity.

By identifying areas at high risk of yield reduction, soil degradation, and water scarcity, this workflow supports planning for more resilient agricultural practices, improved irrigation strategies, and enhanced drought preparedness. It provides Libohova with a structured approach to anticipate drought impacts and strengthen the resilience of both rural households and the local economy.

2.2.3 Choose Scenario

Within the framework of the National Strategy for Climate Change Adaptation, outputs from regional climate models are applied to future time horizons under scenarios of moderate and high increases in global greenhouse gas (GHG) emissions and concentrations through the end of the century. For Libohova Municipality, the choice of scenarios was guided by both climatic and socio-economic considerations, ensuring that the analysis supports long-term, risk-informed decision-making.

The medium-term horizon of 2050 was selected as a practical timeframe for the implementation of public policies and investment planning. Hazard assessments based on return periods of 50, 100, and 500 years provide valuable insights into medium- and long-term risk exposure.

To better capture the potential impacts of climate change, two high-emission RCP4.5 and RCP8.5 scenario were adopted. This pathway offers a cautious estimate of climate risks, projecting more frequent and intense extreme weather events. In the case of Libohova, three hazard categories are particularly significant: river flooding, heavy rainfall and droughts, each expected to intensify under future climate conditions.

Although socio-economic assumptions were not quantitatively modelled at this stage, they remain essential contextual factors. In Libohova, population decline is expected to reshape demographic dynamics, potentially reducing labour availability while also altering community resilience. At the same time, changes in land use, including shifts from agricultural to urban or other economic activities, may increase exposure to climate hazards by reducing natural buffers and expanding settlement into vulnerable areas. Furthermore, the growing demand for infrastructure and public services, driven by evolving community needs and development pressures, will heighten vulnerability if expansion occurs in hazard-prone zones or without climate-resilient standards.

By integrating these socio-economic trends with physical hazard projections, the scenario assumptions provide a more comprehensive understanding of future risks for Libohova Municipality.

2.3 Risk Analysis

This section outlines how risk workflows from the CLIMAAX Manual were systematically applied in Libohova Municipality to evaluate flood risk associated with the Drino River basin and its interconnected hydrological network. The area includes several small streams, which present notable hazards during episodes of intense rainfall, increasing the likelihood of localized flooding.

The analysis integrates hazard, exposure, and vulnerability data to deliver a spatially explicit assessment of flood risk, ensuring that all primary datasets are aligned with CLIMAAX methodological standards. This approach provides a comprehensive framework for understanding how both the Drino River and its smaller tributaries contribute to flood risk under extreme weather conditions in southern Albania.

Key elements of the risk assessment included:

- **Risk Assessment**:

Flood risk in Libohova Municipality was assessed using historical flood depth maps developed by the Joint Research Centre (JRC), covering return periods ranging from 10 to 500 years. To account for future dynamics, climate projections from the Watershed Floods dataset under RCP4.5 and RCP8.5 scenarios were incorporated for the horizons of 2030, 2050, and 2080, offering insights into potential changes in flood severity.

Located within the Drino River basin in southern Albania, Libohova's hydrological system includes several small streams that become particularly hazardous during episodes of intense rainfall, increasing the likelihood of localized flooding. By combining historical flood data with forward-looking climate scenarios, the analysis provides a comprehensive understanding of both current and future flood risks in the municipality.

- **Exposure Assessment**:

The exposure was mapped using detailed land use data (residential, agricultural, industrial), with an emphasis on flood-prone infrastructure in Libohova, such as the city health center, stream banks, and peri-urban agricultural lands. The economic value of the land use categories was integrated through site-specific valuation tables. Due to their location within the Drino River basin, peri-urban areas of Libohova are particularly exposed to climate-related hazards. Heavy rainfall events often overwhelm poorly designed drainage systems, leading to surface runoff, localized flooding, and landslides. Settlements built along slopes or near stream corridors face heightened risks, especially where urban expansion has encroached into hazard-prone terrain.

- **Vulnerability Assessment**:

Vulnerability in Libohova Municipality was examined through a set of demographic and socio-economic indicators, with particular attention to groups such as the elderly, children, people with disabilities, and low-income households. These populations face heightened risks due to limited adaptive capacity and restricted access to resources during hazard events.

In addition, rural households dependent on agriculture and livestock—especially those located along small streams within the Drino River basin—were considered highly vulnerable. Their exposure stems from the risk of economic disruption, soil degradation, and damage to productive land during episodes of heavy rainfall and flooding.

By combining demographic sensitivity with livelihood-based exposure, the analysis highlights how Libohova's rural and peri-urban communities are particularly at risk, underscoring the need for targeted adaptation measures to strengthen resilience.

2.3.1 Workflow #1 - Extreme precipitation

Table 2-1 Data overview workflow #1 - Extreme precipitation

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
EURO-CORDEX precipitation flux projections (12 km resolution; RCP4.5, RCP8.5)	….		Areas at risk of pluvial flooding under future rainfall extremes; exceedance of critical thresholds
Rainfall intensities by duration and return period (e.g., 1h, 3h, 6h events)	….		

2.3.1.1 Hazard assessment

Key findings highlight the following trends:

- EURO-CORDEX model outputs (12 km resolution) under RCP4.5 and RCP8.5 scenarios show a marked intensification of short-duration rainfall events (1–6 hours) by 2050 and 2080.
- The occurrence of 10- and 20-year return period rainfall events is expected to rise, particularly during late summer months.
- Urban and peri-urban areas with a high proportion of sealed surfaces are especially vulnerable to these short, high-intensity rainfall episodes.
- In many modelled scenarios, projected rainfall surpasses the design thresholds of existing drainage systems, posing significant risks for older or informal settlements.

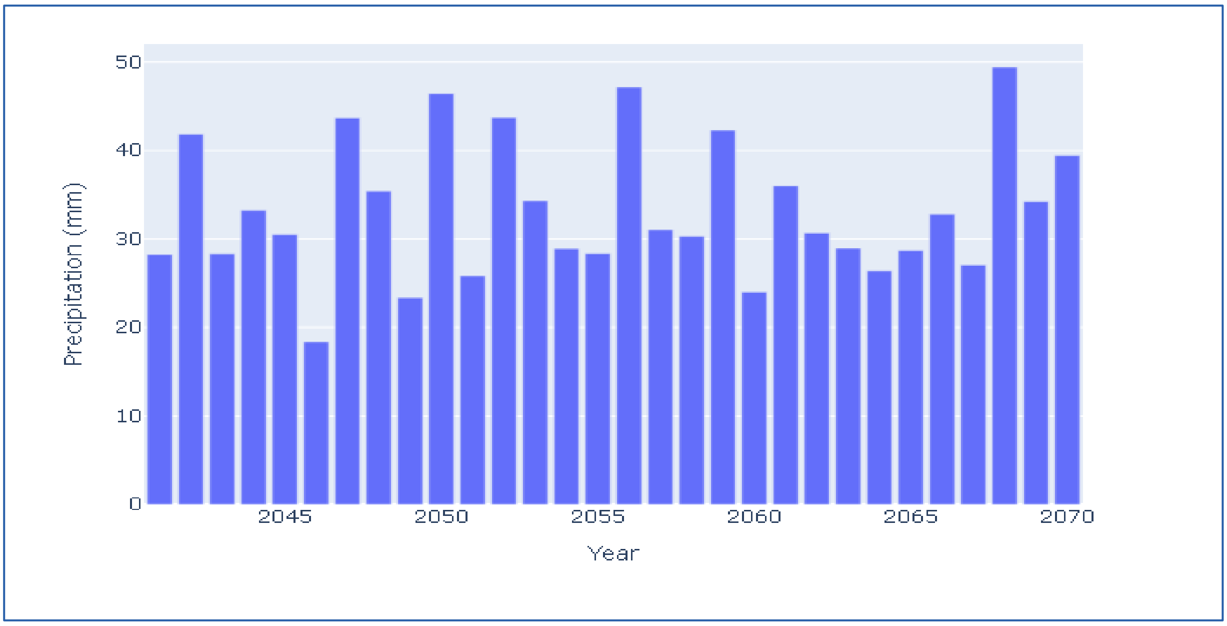

Figure 2.3-1 Annual maximum precipitation for 3h duration in Libohova

Flash floods caused by extreme precipitation are identified as the primary hazard risk in the Drino River basin, and climate change is expected to increase both the frequency and severity of such events. Following the analysis of the extreme precipitation workflow, it was selected for a regional-scale assessment covering the entire basin, as this broader scope provides valuable insights into the cumulative impacts of extreme rainfall across the area.

Figure 2.3-1 illustrates the temporal evolution of annual maximum precipitation for a 3-hour duration at a selected location in Libohova, based on EURO-CORDEX regional climate projections under the RCP8.5 scenario for the period 2041–2070.

The time series was extracted from newly generated netCDF files containing annual precipitation maxima for different accumulation durations. A reference point defined by geographic coordinates (40.0°N, 20.3°E) was reprojected to the EURO-CORDEX coordinate system, and the closest model grid cell was used to represent local conditions in Libohova.

The bar chart reveals clear year-to-year variability in short-duration extreme precipitation. Annual maximum 3-hour rainfall values typically range between 15 mm and 45 mm, with several years showing notably higher peaks, particularly around the middle of the projection period. These peaks reflect years with more intense short-duration rainfall events, while other years are characterized by more moderate extremes.

Overall, the time series does not show a consistent increasing or decreasing trend. However, the repeated occurrence of high annual maxima throughout the period indicates that intense short-duration precipitation remains a significant climate hazard for Libohova under a high-emission scenario. This analysis contributes to hazard characterization within the Climate Risk Assessment and provides a useful basis for further local-scale analyses, such as intensity–duration–frequency (IDF) assessments and impact-oriented evaluations.

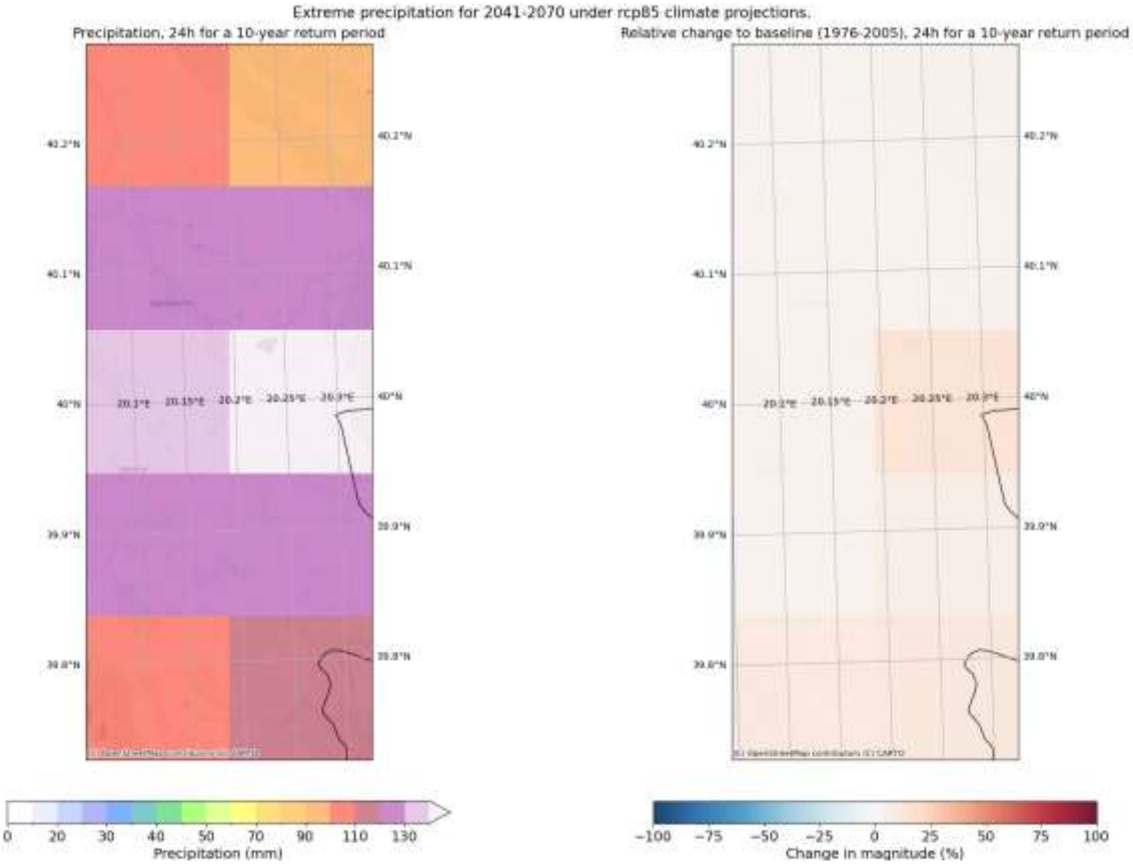

Figure 2.3-2 Extreme precipitation for 2041 - 2070munder RCP8.5 climate projections

The relative change in magnitude of these extreme precipitation events, is variable within the Libohova Municipality territory, with the most important increase for the 2071-2100 future period.

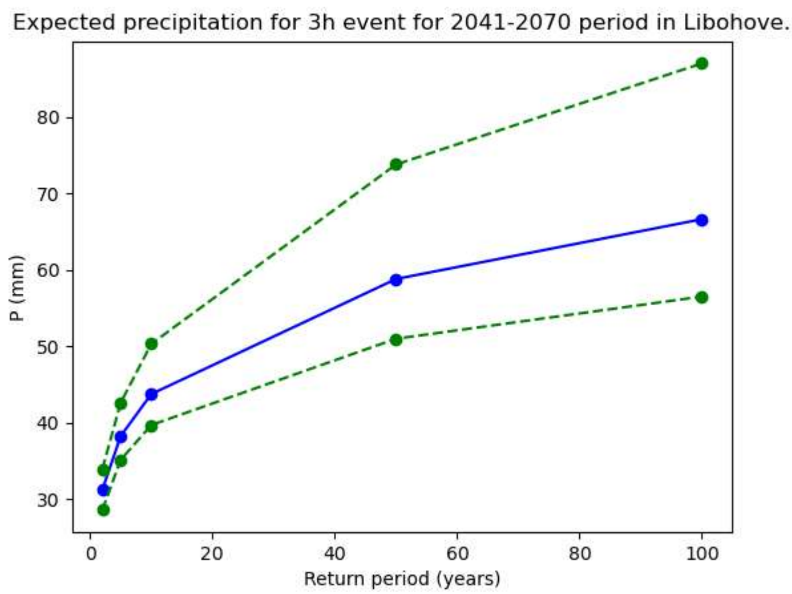

Figure 2.3-3 Expected precipitation for 3h event for 2024 - 2070 period in Libohova

For all the future periods, we could expect in general an increase of these extreme precipitation events (3h and 100-year return period), with the exception of 2041-2070 period, when for some part of the Libohova area we could expect a decrease, comparing with the reference historical period (1976-2005).

2.3.1.2 Risk assessment

The risk analysis integrates climate hazard projections with urban exposure data and vulnerability indicators to identify where extreme precipitation could result in localised flooding.

2.3.2 Workflow #2 – Floods

The second workflow applied in the Climate Risk Assessment focuses on seasonal floods, which pose a recurring threat to infrastructure, water quality, and community safety in Libohova Municipality. Flooding is most common in low-lying areas near streams, river corridors, and poorly drained urban zones, particularly in peri-urban settlements and agricultural fields adjacent to the Drino basin.

This workflow highlights how intense rainfall events exacerbate existing vulnerabilities in Libohova, underscoring the need for targeted mitigation measures such as improved drainage systems, resilient infrastructure planning, and preparedness strategies for at-risk communities.

Table 2-2 Data overview workflow #2- Floods

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
River flood hazard maps for Europe and the Mediterranean Basin region – Copernicus (depths over return periods 10, 100 and 500)	LUISA depth damage curves for land use - JRC	Europe LUISA Land Cover base map 2018 100m resolution JRC)	River flood hazard maps for 10, 100, 500 years RP for present day scenario Flood damage maps, expressed in economic value, for extreme events with different return periods based on available flood maps for the historical climate
Future river flood maps (Aqueduct; RCP4.5 & RCP8.5)			Comparative analysis of flood risk change under climate scenarios (2030, 2050, 2080)

2.3.2.1 Hazard assessment

The flood hazard map highlights areas within Libohova Municipality that are most exposed to seasonal flooding, particularly low-lying zones near streams and river corridors of the Drino basin. Based on precipitation anomalies and terrain analysis, the map identifies several peri-urban areas and agricultural fields adjacent to waterways as high-risk zones.

This visualization supports the identification of flood-prone areas in Libohova and provides a basis for the prioritization of mitigation measures, including improved drainage systems, resilient infrastructure planning, and targeted preparedness actions for vulnerable communities.

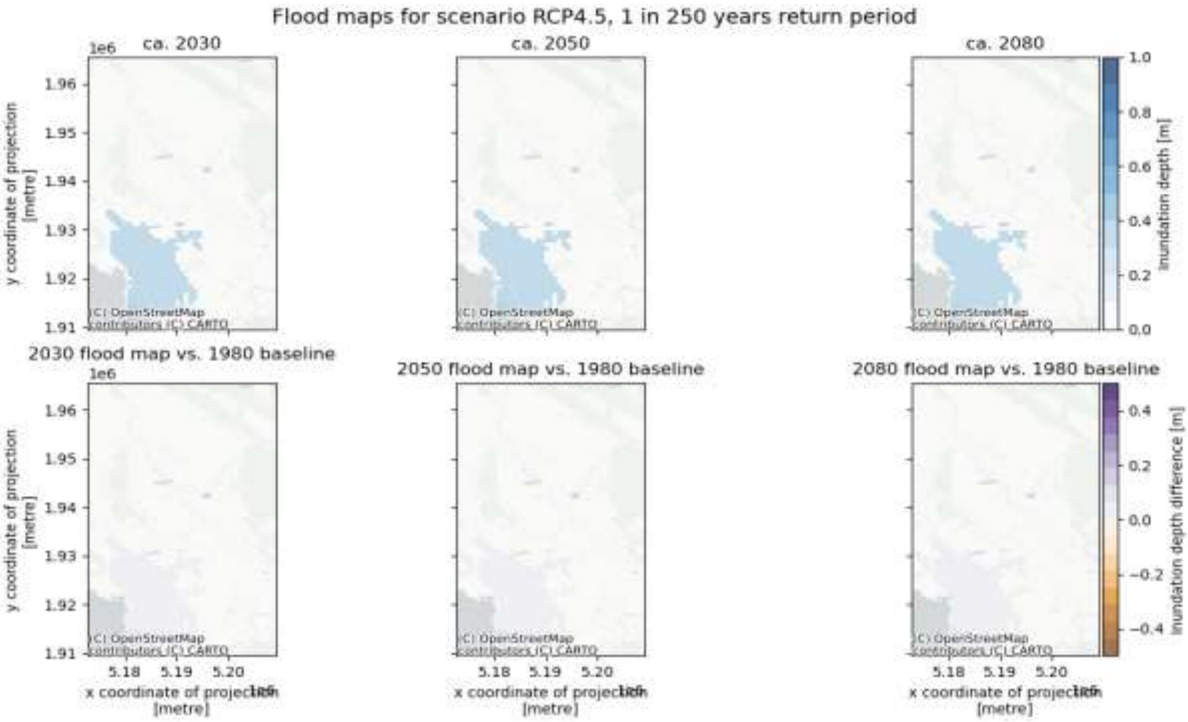

Figure 2.3-4 Flood maps for scenario RCP4.5, 1 in 250 years return period

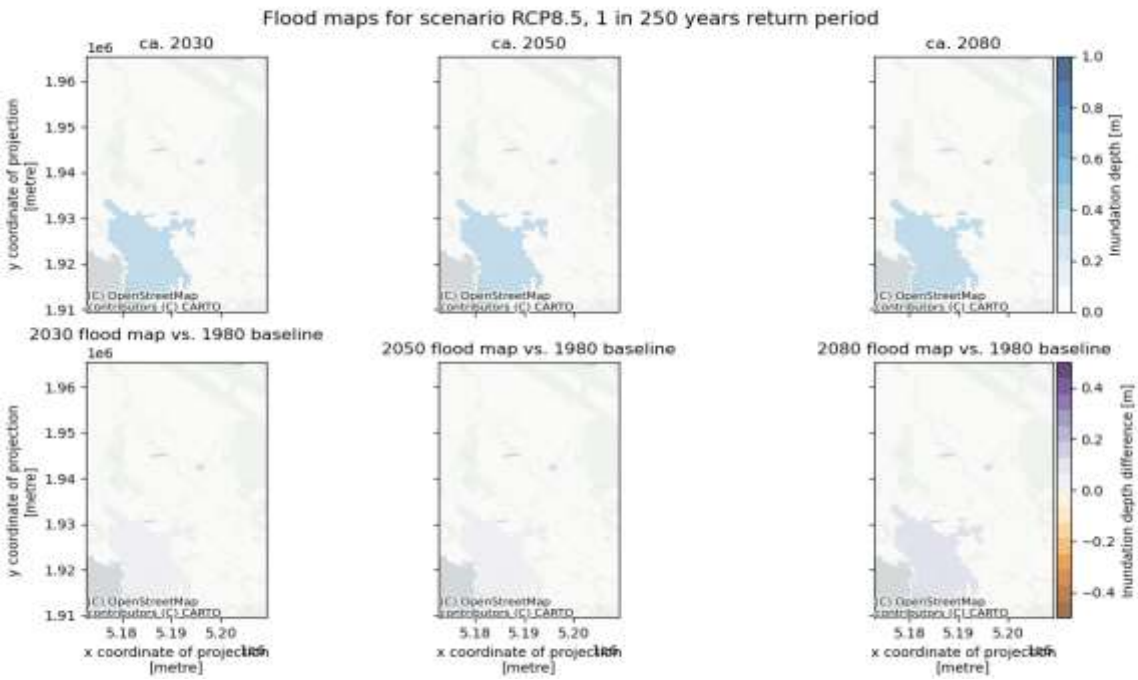

Figure 2.3-5 Flood maps for scenario RCP8.5, 1 in 250 years return period

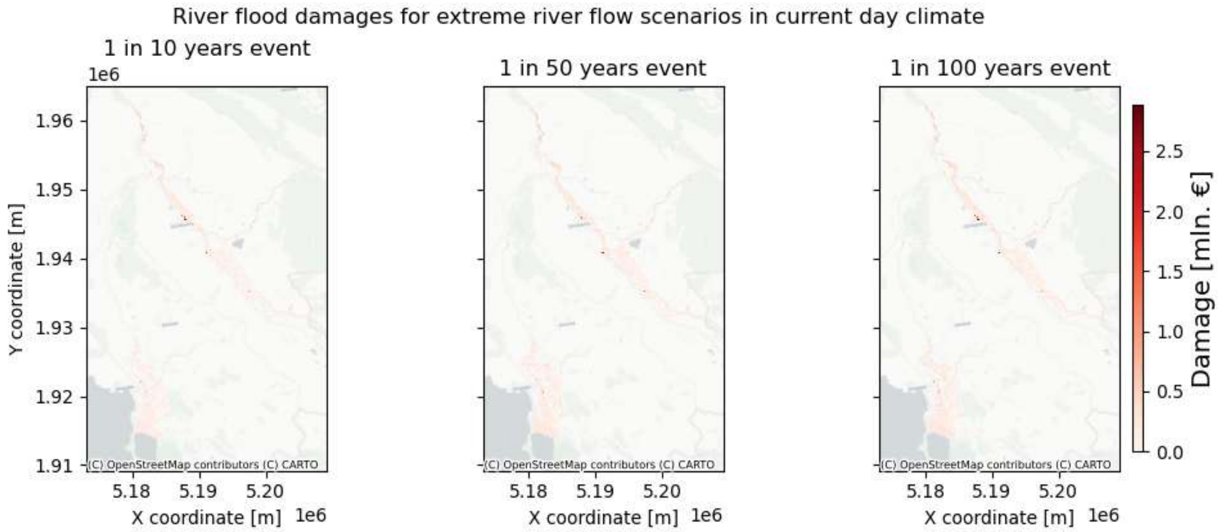

Figure 2.3-8 Maps of flood and associated damages for extreme river water level scenarios in current climate 1 in 100 years

Figure 2.3-7 River flood potential for different return periods (present-day scenario ca. 2018)

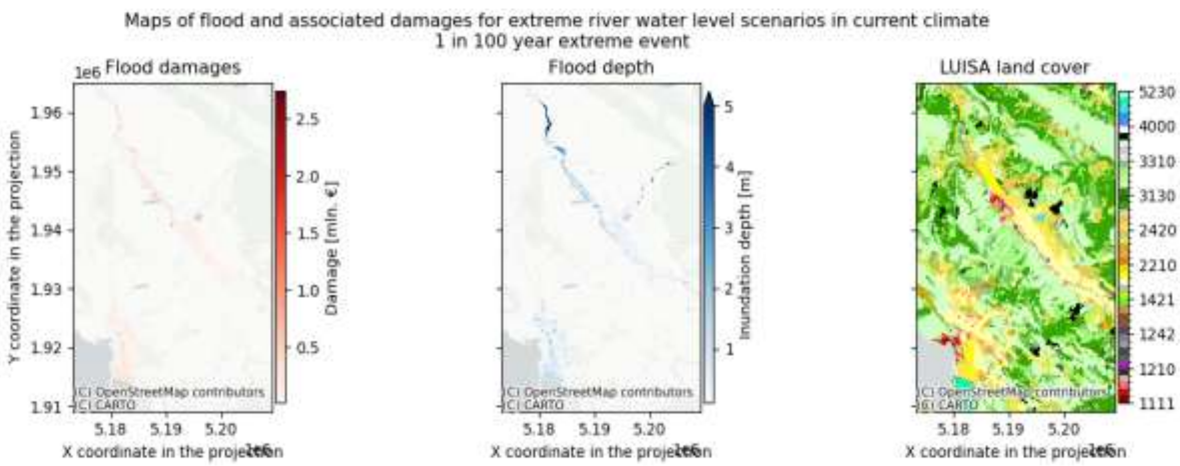

Figure 2.3-6 Maps of flood and associated damages for extreme river water level scenarios in current climate 1 in 100 years

2.3.2.2 Risk assessment

The flood hazard map highlights areas within Libohova Municipality that are most exposed to seasonal flooding, particularly low-lying zones near streams and river corridors of the Drino basin. Based on precipitation anomalies and terrain analysis, the map identifies several peri-urban areas and agricultural lands adjacent to waterways as high-risk zones.

This visualization supports the identification of flood-prone areas in Libohova and informs the prioritization of mitigation measures, including improved drainage infrastructure, strengthened flood defences, and targeted preparedness strategies for vulnerable communities.

2.3.3 Workflow #3 – Flood damage and population exposure

The Flood Damage and Population Exposure workflow was applied to the territory of Libohova Municipality, situated within the Drino River basin, where risks linked to population concentration, displacement, and structural damage to buildings were identified. The analysis of river flood hazards for the Drino basin was carried out in alignment with the River Flood workflow, making use of the River Flood Hazard Maps for Europe and the Mediterranean Basin Region dataset, after establishing the geographical boundaries of the study area.

This workflow highlights how seasonal and extreme flood events can significantly affect both settlements and infrastructure in Libohova, providing a basis for targeted measures to reduce exposure and strengthen community resilience.

Table 2-3 Data overview workflow #3-Flood damage and population exposure

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
River flood hazard maps for Europe and the Mediterranean Basin region –Copernicus (depths over return periods 10, 100 and 500)	Inundation depth thresholds for population displacement		Maps of exposed population Estimated annual exposed population graph Maps of displaced population Estimated annual displaced population graph
Number of hot days per year; heatwave duration indicators	Damage curves for buildings European Commission's Joint research Centre		Building damage maps Estimated annual building damage graph

2.3.3.1 Hazard assessment

The Building and Population Flood Risk Assessment workflow was initially applied across the entire stretch of the Drino River basin within Libohova Municipality. However, a detailed review of the available exposure datasets revealed that only specific localities within the basin were sufficiently represented. Due to these data constraints, the workflow was refined to concentrate on the section of the river passing through Libohova's territory, where coverage is adequate and the area is recognized as highly vulnerable to flooding during extreme events.

The evaluation of flood risk and its impacts on both buildings and population followed the methodology of the Building and Population Floods workflow, which estimates potential economic damages to structures using damage curves, EU-level economic parameters, and building typologies. It also assesses exposed and displaced populations through population distribution datasets.

After defining the geographical boundaries of Libohova and selecting return periods of interest (10, 100, and 500 years), flood extent and water depth rasters were retrieved from the Copernicus Earth Monitoring Service (Zenodo WF3). The 100-year return period flood map indicates that, during an event with a 1% probability of occurrence, areas adjacent to the Drino River within Libohova face a moderate risk of flood depths reaching up to 10 meters.

Estimated population density data for Libohova Municipality were obtained from the European Commission's Joint Research Centre for the year 2025, expressed as the number of inhabitants per grid cell. Although Libohova is a relatively small locality, its socio-economic importance is reinforced by the presence of a recognized tourist destination.

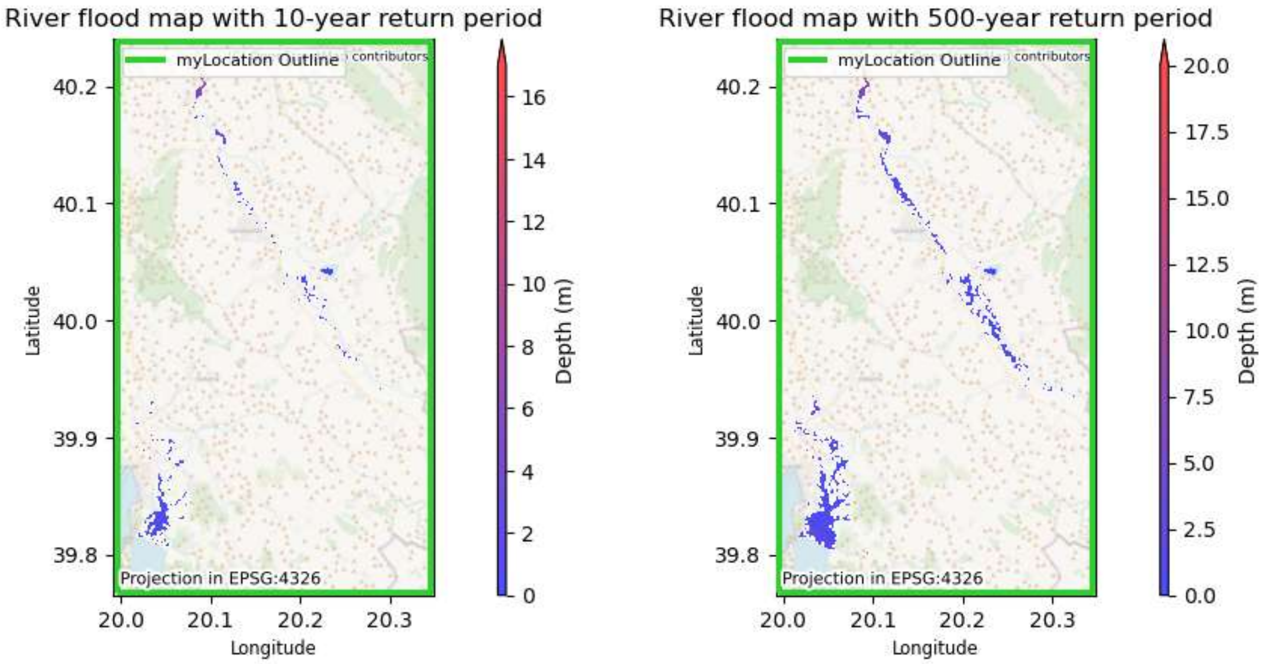

Figure 2.3-9 River flood hazard map with 10 and 500-years RP for Libohova area

As a result, the local population increases significantly during the tourist season, rising from approximately 2,000 permanent residents to more than 3,000 inhabitants when visitor numbers peak. This seasonal fluctuation highlights the municipality's dual vulnerability: the challenges of managing risks for a small resident population, combined with the added pressures of a temporary surge in exposure during tourism periods

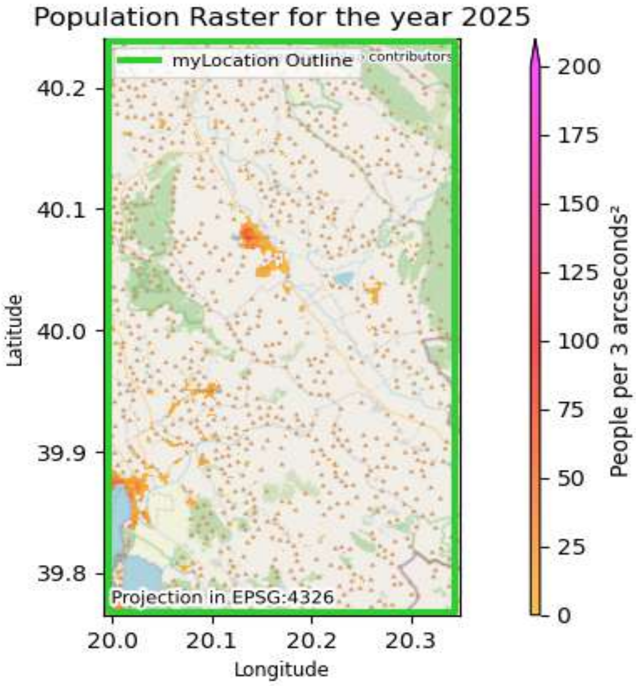

Figure 2.3-10 Population density map for Libohova area

For Libohova Municipality, building information was sourced from OpenStreetMap, which provides details on the location and geometry of structures across the area. Since the dataset does not include specific building type classifications, all structures were grouped under a generalized "Universal" category for the purposes of the assessment.

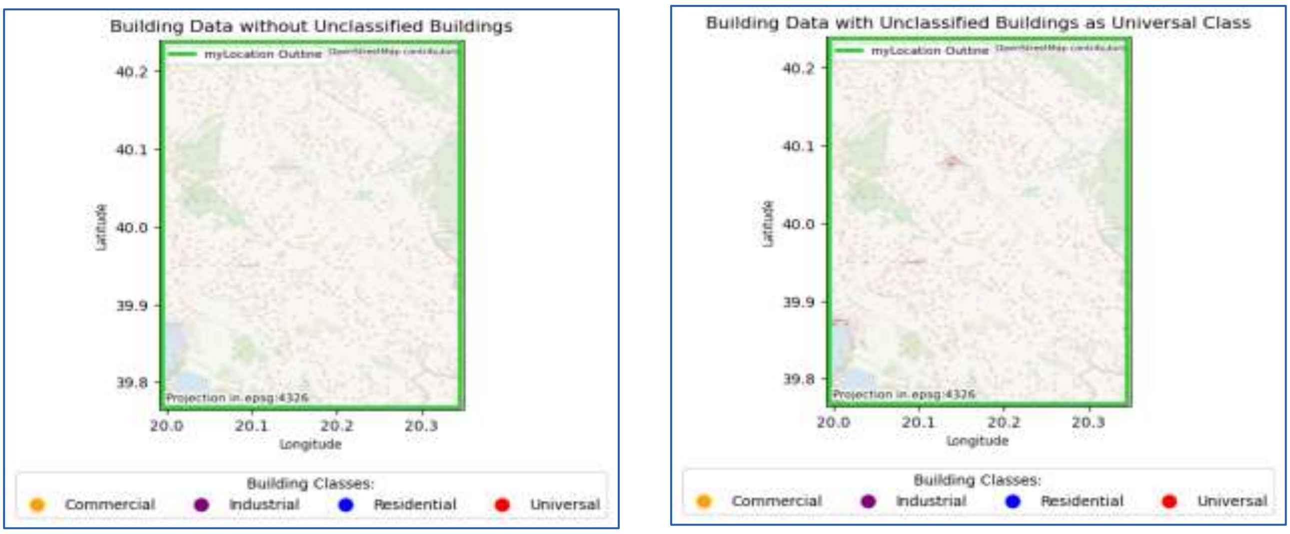

Figure 2.3-11 Building locations map for Libohova area

This approach ensures consistency in the analysis while acknowledging the limitations of the dataset, particularly in differentiating between residential, commercial, and public buildings. (Figure 2.3-11).

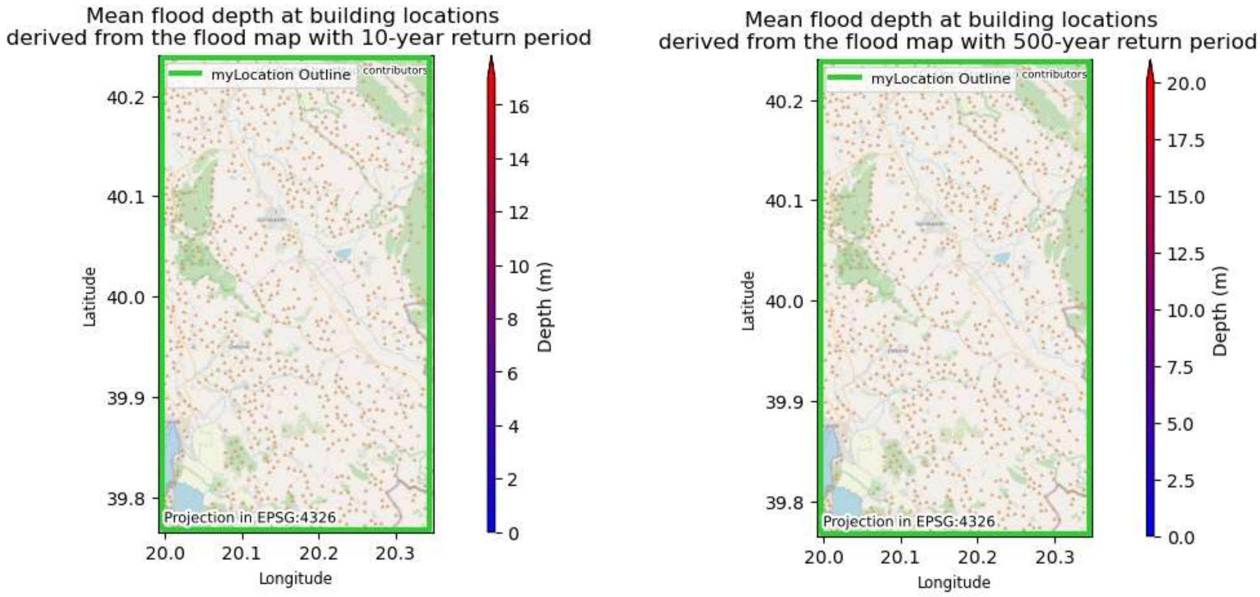

Figure 2.3-12 Mean flood depth building locations map for Libohova area for the event with 10 and 500-years RP

The next stage of the workflow involved producing flood depth maps for building locations in Libohova Municipality, derived from flood depth rasters corresponding to 10-year and 500-year return periods, combined with the building dataset.

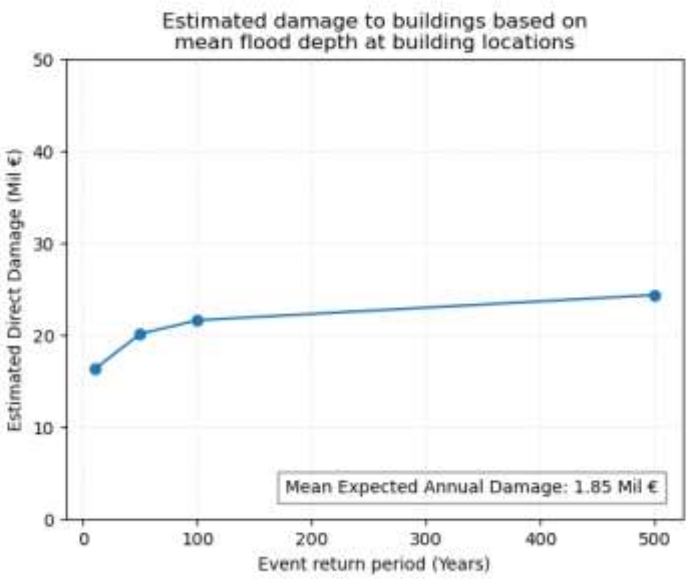

Figure 2.3-13 Estimated damage to building for Libohova area on mean flood depth for different RP

The mean flood depth map for the 1% probability event (100-year return period) shows that nearly all building sites across Libohova are subject to substantial flood depths during such extreme events. This outcome highlights the municipality's high exposure to riverine flooding, emphasizing the need for targeted resilience measures to protect both residential and public infrastructure.

Based on the calculated flood depths, the potential economic losses to buildings—expressed as reconstruction costs—were estimated using the JRC damage function for Universal buildings (an average curve representing residential, commercial, and industrial structures). The calculation combined the maximum damage value per square meter with the footprint area of each building.

From this, damage maps and plots were generated for the selected return periods, and the total building damage for Libohova Municipality was assessed. The results indicate that reconstruction costs for the community range from approximately €16 million for a 10-year return period flood to about €24 million for a 500-year return period flood (Figure 2.3-13).

These damages are particularly critical given that local communities in Libohova Municipality have limited resources to strengthen climate and disaster resilience and often lack the capacity to adequately implement emergency response and recovery measures.

In line with the workflow steps, population density data for Libohova were integrated with flood depth rasters to generate maps of the population exposed across the selected return periods. The exposed population was then compared against the flood scenarios, and the expected annual exposed population was calculated—representing the average number of individuals likely to be affected in any given year.

This analysis underscores the dual challenge for Libohova: addressing both the structural damages to buildings and the direct impacts on vulnerable populations, particularly under extreme flood events.

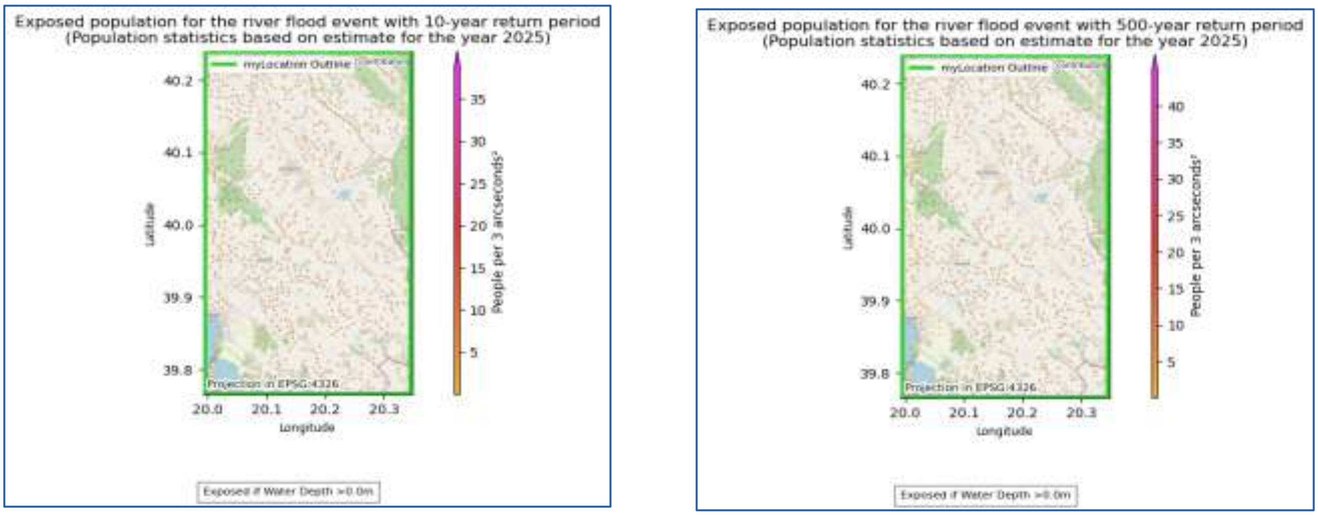

Figure 2.3-14 Map of exposed population in Libohova area for the flood event with 10 and 500-years RP

Using flood depth rasters in combination with population density maps, the number of displaced residents in Libohova Municipality was estimated by applying a threshold of water depth greater than 1.0 m. The resulting graphs of exposed and displaced populations across the selected return periods show comparable values, ranging from about 2,600 individuals for a 10-year flood event to nearly 4,000 individuals for a 500-year flood scenario.

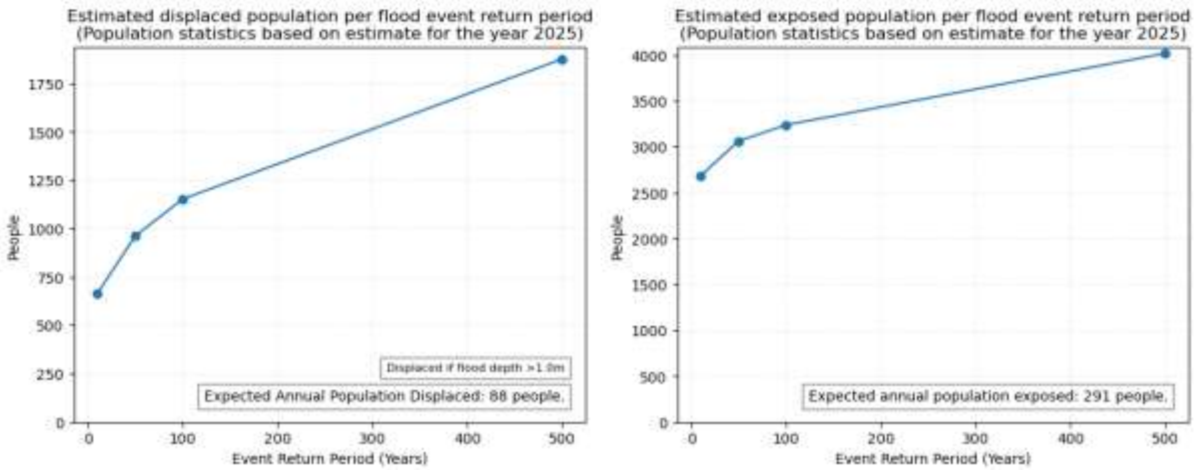

Figure 2.3-15 Estimated exposed population in Libohova area for different RP of flooding event

These maps and plots illustrate how building damage, population exposure, and displacement vary according to flood recurrence intervals. The same workflow was also applied to the building damage analysis, using the available dataset in the notebook. This produced graphs (Figures 2.3-16) showing the exposed and displaced population for 10- and 500-year flood events, when water depth exceeds 0.0 m.

2.3.4 Workflow #4 – Agriculture droughts

The assessment of agricultural drought risk in Libohova Municipality was carried out using indicators of soil moisture deficit and precipitation anomalies, derived from regionalized drought indices such as the Standardized Precipitation–Evapotranspiration Index (SPEI). These indicators provide insight into the extent and severity of drought conditions affecting agricultural land and rural livelihoods in the municipality.

A detailed overview of the underlying data and methodology is presented in Table 2-4, which supports the characterization of drought hazards and informs the integration of resilience measures into the local climate risk framework.

Table 2-4 Data overview workflow #4-Agriculture droughts

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Daily mean precipitation, maximum and minimum temperature, 2m relative humidity, surface downward solar radiation, and 10m wind speed, derived from EURO-CORDEX EUR-11 climate projections (MPI-SMHI) for future periods (2036–2065) under RCP8.5 scenario	Soil available water capacity		Revenue losses from irrigation deficit expressed as 'lost opportunity cost' in thousand euros
Precipitation deficit leading to yield loss in key regional crops (e.g., maize, wheat, barley, potato, tomato, beans, peppers)	Share of cropland with irrigation systems Thermal climate zone Elevation		Building damage maps Estimated annual building damage graph

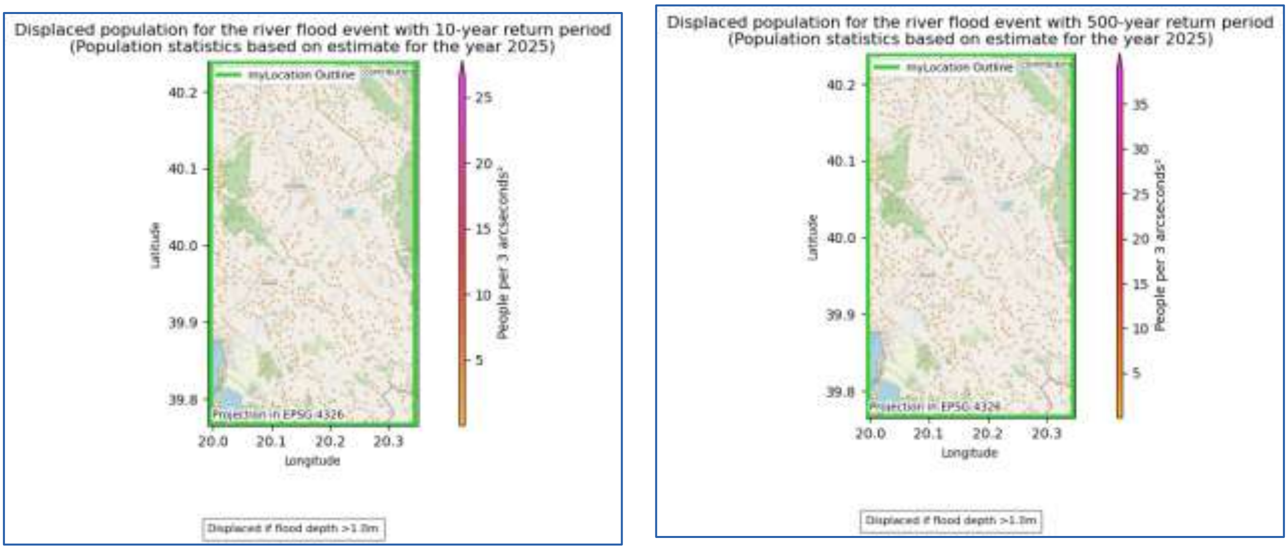

Figure 2.3-16 Displaced population for the river flood events with 10 and 500-years RP

2.3.4.1 Hazard assessment

Based on the analysis of available soil water capacity, combined with accumulated precipitation intensity and standard evapotranspiration throughout the growing season, it was possible to estimate yield reductions for key crops in Libohova Municipality, including beans, corn, legumes, and rice.

The results indicate that bean production is expected to experience the most severe losses due to precipitation deficits, with reductions exceeding 50–60% across much of the municipality's agricultural land. This highlights the particular vulnerability of bean cultivation to drought conditions and underscores the importance of integrating climate-resilient practices into local agricultural planning.

2.3.4.2 Risk assessment

The risk assessment combined drought hazard maps with land use classifications, crop distribution data, and farm-level vulnerability indicators. The findings show that potato and rice cultivation in Libohova Municipality are expected to experience the highest revenue losses due to precipitation deficits.

In general, farms with limited irrigation infrastructure and those cultivating water-dependent crops face the greatest risk of reduced productivity. Although not explicitly presented in the results, drought conditions are also anticipated to negatively affect livestock farming, primarily through reduced forage availability and increased heat stress.

These outcomes emphasize the importance of adopting water efficiency measures, promoting drought-tolerant crop varieties, and developing insurance mechanisms tailored to the needs of smallholder farmers and cooperatives in Libohova.

2.4 Preliminary Key Risk Assessment Findings

2.4.1 Severity

The main results from Phase 1 of the Climate Risk Assessment (CRA) focus on the identification and mapping of hotspots with elevated hazard and risk levels across Libohova Municipality, while also providing preliminary insights into how climate change may shape the future evolution of selected hazards. These findings establish the groundwork for the more detailed, localized CRA that will be undertaken in Phase 2 of the project.

The primary climate-related risks affecting Libohova are intense rainfall, riverine flooding, and flash floods. Despite the limitations of the datasets used, the Phase 1 outputs consistently highlight multiple areas with high hazard and risk values for the selected return period events, alongside a clear upward trend in risk under future climate scenarios.

2.4.2 Urgency

In Libohova Municipality, extreme rainfall emerges as the most pressing hazard requiring urgent short- and medium-term adaptation measures. Both the frequency and intensity of such events are increasing under climate change and are projected to worsen in the coming decades. Without timely interventions, climate-induced disasters are expected to intensify almost annually.

Immediate priorities include:

- Reinforcing critical infrastructure
- Upgrading urban drainage systems
- Establishing early warning mechanisms for floods and flash floods
- Monitoring landslide-prone areas
- Constructing retaining walls on vulnerable slopes
- Raising public awareness on disaster preparedness

Extreme rainfall represents the primary climate challenge for Libohova, posing serious risks to public health, the local economy, and infrastructure if robust adaptation measures are not implemented.

To address this, comprehensive short-, medium-, and long-term adaptation strategies should be developed to foster disaster-resilient urbanization. Expanding disaster insurance schemes will help mitigate economic losses, while strong partnerships at local and national levels are essential to design and implement effective action plans for risk reduction, emergency response, and recovery.

2.4.3 Capacity

In Libohova Municipality, although still at an early stage, several initiatives to reduce climate-related risks have already been launched. In August 2025, the municipality began preparing an Action Plan for Natural Disaster Management, marking an important first step toward strengthening institutional capacity. The plan, designed to mitigate risks from floods, landslides, and other hazards linked to extreme rainfall, outlines a set of activities aimed at advancing climate risk reduction.

Planned measures include ensuring that residents are well informed about climate risks, raising awareness levels, and building a resilient community capable of withstanding disasters. In parallel, planning has also been undertaken to promote sustainable and disaster-resistant living spaces. However, successful implementation of the Action Plan will require additional financial resources.

As a second step, the Municipality of Libohova has engaged with international initiatives such as the CLIMAAX project, further enhancing its capacity for climate risk management. In conclusion, while current measures have achieved partial effectiveness, Libohova urgently needs a comprehensive, proactive, and well-funded strategy to address climate change. The CLIMAAX project is expected to play a key role in shaping and implementing such a strategy.

2.5 Preliminary Monitoring and Evaluation

Through the activities of Phase 1 of the Climate Risk Assessment (CRA), practical experience was gained in applying the framework and utilizing the toolbox to generate relevant outputs for Libohova Municipality. Due to the specific characteristics of the area, certain adjustments were required to adapt the analytical notebooks. When interpreting the results, it was essential to take into account both the strengths and the limitations of the datasets available within the CRA.

Some challenges were encountered with the extreme precipitation workflow, particularly in understanding the details of the processing steps. To improve clarity, it would be beneficial to prepare schematic representations (data processing diagrams) for each workflow. In addition, the precise geographical details and projections associated with the bias-corrected and thresholded datasets were not fully understood and will be revisited in greater depth during Phase II.

According to the project work plan, three workshops will be organized with key stakeholders and beneficiaries in the study area: one preparatory meeting in September 2025 (Phase 1), followed by two workshops in March and June 2026 (Phases 2 and 3) for stakeholder consultation and dissemination of results. These workshops will inform participants about the project and its implementation stages, engage them directly in consultations, and involve them in finalizing new proposals for a program of measures addressing prevention, protection, and preparedness for current and future floods under climate change conditions.

For a more robust assessment of climate change impacts on river flood and flash flood risks, the most critical data required are maximum discharge values and the percentage changes in these values under current and future scenarios.

2.6 Work plan

The upcoming phases of the **CLEAR-AL** project will concentrate on deepening the climate risk analysis, refining adaptation priorities, and co-developing actionable strategies with local stakeholders. The work plan is structured around the following core activities:

Main Activities to Be Studied

- **Validation of Risk Maps and Indicators -** Risk outputs from the three workflows (extreme rainfall, floods, flood damage and population exposure) will be reviewed with municipal staff, community representatives, and technical experts to ensure local relevance and accuracy.
- **Prioritization of Adaptation Measures** - Based on severity, urgency, and capacity findings, targeted interventions will be identified for high-risk zones. These may include nature-based solutions, infrastructure upgrades, and public awareness campaigns.
- **Integration into Municipal Planning** - Climate risk findings will be embedded into local development plans, emergency response protocols, and sectoral strategies (e.g., agriculture, water, health).

- **Stakeholder Engagement and Capacity Building -** Workshops and consultations will be organized to strengthen institutional ownership, build technical capacity, and ensure inclusive participation, particularly of vulnerable groups.
- **Monitoring Framework Design -** A preliminary set of indicators and tools will be proposed to track adaptation progress, institutional responsiveness, and community resilience over time.

Aspects Not Studied and Justification

- **Sea Level Rise and Coastal Hazards** – excluded due to Libohova's inland geography and lack of exposure to marine systems.
- **Industrial Emissions and Urban Heat Island Effects** – not prioritized, as Libohova has limited industrial activity and low urban density, making these risks less relevant in the current context.
- **Detailed Economic Modelling** – while financial impacts are considered qualitatively, complex macroeconomic simulations are beyond the scope and resources of this phase.

3 Conclusions Phase 1- Climate risk assessment

The first phase of the **CLEAR-AL** project has established a foundational understanding of the climate risks affecting the municipality, applying the CLIMAAX methodology to systematically assess five key hazards: droughts, floods, heatwaves, soil erosion, and wildfires. Through a combination of spatial analysis, stakeholder engagement, and scenario-based modelling, the assessment generated actionable insights into the severity, urgency, and distribution of climate threats across Libohova.

Main Conclusions

- **Integrated Risk Mapping –** CLIMAAX workflows enabled the creation of hazard-specific risk maps, identifying high-risk zones for each climate hazard. These maps provide both a visual and analytical basis for prioritizing adaptation measures**.**
- **Severity and Urgency Differentiation –** Droughts and heatwaves emerged as the most severe and urgent risks, with frequency and intensity projected to increase under RCP4.5 and RCP8.5 scenarios. Floods and wildfires, while episodic, pose acute threats to infrastructure and ecosystems. Soil erosion, though slower in onset, contributes to long-term land degradation.
- **Capacity Gaps Identified –** The assessment revealed financial, technical, and institutional limitations in managing climate risks. While some measures exist—such as awareness campaigns and pilot interventions—there is a need for stronger coordination, data systems, and long-term planning**.**
- **Stakeholder Engagement as a Strength –** Participatory consultations enriched the analysis, ensuring that local knowledge and lived experiences informed the identification of vulnerable zones and populations. However, the engagement of marginalized groups remains limited and will require targeted outreach in future phases.
- **Scenario-Based Planning Validated –** The use of CLIMAAX scenarios framed the urgency of action, particularly for heat-related hazards and water stress, and will be critical in shaping medium- and long-term adaptation strategies.

Challenges Addressed

- Developed a multi-hazard risk profile using harmonized data sources.
- Initiated stakeholder dialogue and raised awareness of climate risks.
- Identified priority zones for intervention based on severity and exposure.

Challenges Not Fully Addressed

- Limited availability of high-resolution and real-time data, especially for flood history and population exposure dynamics.
- Gaps in forecasting infrastructure and early warning systems.
- Need for deeper integration of climate risks into municipal planning and budgeting.
- Insufficient representation of vulnerable populations in decision-making processes.

Key Findings

- **High-risk zones** include low-lying urban areas (floods), sloped agricultural lands, and peri-urban zones with limited vegetation**.**
- **Vulnerable groups** include elderly residents, outdoor workers, and livestock-dependent households.
- **Urgent action** is required within the next 2–5 years to prevent irreversible damage, particularly in agriculture, water management, and public health**.**
- **Nature-based solutions** and **inclusive governance** are essential pillars for building long-term resilience.

4 Progress evaluation and contribution to future phases

The completion of Phase 1 of the **CLEAR-AL** project marks a critical milestone in establishing a data-driven and participatory foundation for climate risk management. This deliverable—focused on multi-hazard risk assessment—has generated key outputs that directly inform the design and implementation of the next project phases, including adaptation planning, stakeholder engagement, and monitoring frameworks.

The outputs of this phase—risk maps, severity and urgency profiles, and capacity assessments—will serve as baseline references for:

- **Adaptation Prioritization** – Identifying high-risk zones and vulnerable populations for targeted interventions.
- **Municipal Integration** – Embedding climate risk indicators into local development plans and emergency protocols.
- **Stakeholder Mobilization** – Expanding engagement to include underrepresented groups and sectoral actors.
- **Monitoring and Evaluation Design** – Establishing performance indicators and feedback loops for resilience tracking.

These activities will build on the spatial and institutional insights generated in Phase 1, ensuring continuity and coherence across project phases.

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
2 workflows successfully applied on Deliverable 1 (e.g., data collection, risk identification, vulnerability mapping)	• Workflow Adaptation and Application – The workflows for River Flooding and Heavy Rainfall/Extreme Precipitation were adapted to the context of Libohova Municipality and applied for the relevant return periods and scenarios. • Flood Damage and Population Exposure Analysis – The workflow for Flood Damage and Population Exposure was included in the plan and successfully implemented. • Comprehensive Output Analysis – All outputs generated from the adapted workflows were systematically reviewed and analysed, providing a solid evidence base for subsequent phases of the project
10 stakeholders involved in Phase 1 activities, including local authorities, farmers, community leaders, and technical experts	Introductory Workshop Completed – An initial workshop was successfully held with municipal staff, farmers, youth representatives, and environmental NGOs to present project objectives and gather feedback.
4 communication actions taken during Phase 1 to share preliminary findings with stakeholders (e.g., workshops, newsletters, meetings)	Progress on the KPI has been demonstrated through the implementation of two communication actions during Phase 1, including stakeholder workshops and targeted newsletters, which served to share preliminary findings and foster dialogue. These activities represent half of the planned four communication

Key performance indicators	*Progress*
	actions, ensuring early engagement and laying the groundwork for continued dissemination in the next phase.
Completion of 1 detailed multi-risk profile report for Libohova	Progress on the KPI has been achieved through the completion of one detailed multi-risk profile report for Libohova, providing analysis of key hazards, vulnerabilities, and recommendations to support local resilience and climate adaptation planning.

Table 4-2 Overview milestones

Milestones	*Progress*
M1: Completion of initial data collection and stakeholder engagement	Following the agreement with the CLIMAAX program, the Municipality of Libohova formally established a dedicated implementation team through council and mayoral decisions, assigning municipal specialists across key departments. To strengthen technical capacity, a cooperation agreement was signed with INCA as subcontractor. The initial stakeholder engagement phase successfully mapped local actors and launched inclusive consultations, involving municipal staff, farmers, youth representatives, and environmental NGOs. This process laid the groundwork for participatory project implementation, ensuring that local knowledge and priorities are integrated into the climate risk management framework
M2: Successful application of the CLIMAAX common methodology for multirisk assessment	This milestone marks the successful application of the CLIMAAX common methodology to conduct a multi-risk assessment for Libohova Municipality. Five priority climate hazards were identified: heavy rainfall, river flooding, flood damage, and population exposure, based on historical data, local context, and CLIMAAX scenario projections. An indicator framework was developed to assess each hazard's intensity, exposure, and vulnerability, providing a structured basis for risk analysis in the following phases. This framework ensures consistency across workflows and supports evidence-based decision-making for adaptation planning.
M3: Identification and mapping of vulnerable areas in Libohova	This milestone marks the successful identification and spatial mapping of vulnerable areas within Libohova Municipality. Using the adapted CLIMAAX workflows, hazard-specific risk maps were generated to highlight zones most exposed to flooding, extreme rainfall, drought, and related impacts. The analysis integrated land use data, population distribution, and local vulnerability indicators, enabling the municipality to pinpoint high-risk zones and priority communities requiring targeted adaptation measures. These outputs provide a visual and analytical foundation for decision-making, ensuring that future interventions are directed toward areas with the highest exposure and sensitivity to climate hazards.

Milestones	*Progress*
M4: Delivery of preliminary reporting and multi-risk profile	The first draft of the climate risk assessment report has been completed, consolidating hazard analysis, exposure mapping, and vulnerability profiling.
M5: Attend the CLIMAAX workshop held in Barcelona	Project staff appointed by the Mayor and Municipal Council actively participated in the CLIMAAX workshop held in Barcelona, strengthening their understanding of the methodology and its application.

5 Supporting documentation

The following outputs were produced during Phase 1 of the **CLEAR-AL** project and have been uploaded to the Zenodo repository for open access and future reference. These materials reflect the analytical, visual, and engagement components of the climate risk assessment process:

- **Draft Report** – Deliverable Phase 1: Climate Risk Assessment for the project "Evaluating Vulnerabilities and Optimizing Local Vitality and Ecosystems in Libohova (**CLEAR-AL**)", available in Word and PDF formats.
- **Workshop Documentation** – Invitation, agenda, photos, and participant list from the introductory stakeholder workshop.
- **Workflow 1 – Extreme Precipitation Outputs**
    - WF1_Extreme precipitation_3h_100yearRP (3 maps)
    - WF1 – Other supporting data (Workflow 1)
- **Workflow 2 – River Flooding Outputs**
    - WF2_Floodmap_overview_JRC_PresentScenario
    - WF2_River flood hazard maps (6 maps)
    - WF2_River flood maps_Aqueduct (12 maps)
    - WF2_Damage maps
- **Workflow 3 – Buildings and Population Exposure Outputs**
    - WF3_Hazard_maps_Libohova
    - WF3_Building_damage_maps_graphics
    - WF3_Population_exposure_maps_graphics
    - WF3_Population_exposure_maps

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