CLIMAAX
climate ready regions

Deliverable Phase 2 – Climate risk assessment

Evaluating Vulnerabilities and Optimizing Local Vitality and Ecosystems in Belsh (EVOLVE-Belsh)

Albania, Belsh Municipality

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5 Abbreviations and acronyms

Abbreviation / acronym	Description
AMBU	National Agency for Water Resources Management
CDS	Copernicus Climate Data Store
CLIMAAX	Climate Risk Assessment Framework for European Regions and Communities
CRA	Climate Risk Assessment
DEM	Digital Elevation Model
EFFIS	European Forest Fire Information System
ET0	Reference evapotranspiration
ETa	Actual evapotranspiration
ETc	Crop evapotranspiration
EURO-CORDEX	European Coordinated Regional Climate Downscaling Experiment
EVOLVE-Belsh	Evaluating Vulnerabilities and Optimizing Local Vitality and Ecosystems in Belsh
FWI	Fire Weather Index
GAEZ	Global Agro-Ecological Zones
GEV	Generalized Extreme Value distribution
GIS	Geographic Information System
INCA	Institute for Nature Conservation in Albania
INSTAT	Institute of Statistics of Albania
MapSPAM	Spatial Production Allocation Model
PPV	General Local Territorial Plan / local land-use planning layer used in the GIS analysis
RCP	Representative Concentration Pathway
RP	Return Period
WUI	Wildland-Urban Interface

6 Executive summary

Phase 2 of the EVOLVE–Belsh project under the CLIMAAX Framework delivers a strengthened climate risk assessment for Belsh Municipality. Building on the baseline analysis of Phase 1, this phase integrates updated datasets, hydraulic models, and stakeholder insights to refine risk profiles and prepare actionable adaptation strategies. Belsh's karst landscape, reliance on agriculture, and socio-economic vulnerabilities make it highly exposed to climate variability, underscoring the need for a structured and locally relevant assessment.

Key actions in Phase 2 included:

- Collection and processing of clean climate datasets from Belsh and surrounding meteorological stations.
- Development of rainfall, drought, and temperature indicators supported by geospatial data and historical records of extreme events.
- Engagement of municipal staff, civil society, farmers, youth and women's groups, and technical experts through workshops and consultations.
- Application of CLIMAAX guiding questions to assess severity, urgency, resilience capacity, and risk prioritization, supported by agricultural and water-management datasets, maps, and visual outputs.

The findings highlight three main risks:

- **Extreme rainfall, flooding, erosion, and landslides** – assessed as *substantial in severity*, with *medium resilience capacity* and urgency rated as *more action needed*. Documented damages to buildings, farmland, olive groves, and road infrastructure confirm its designation as **Priority 1**.
- **Meteorological drought and heat-related water stress** – assessed as *moderate to substantial*, with urgency ranging from *watching brief* to *more action needed* and resilience capacity also *medium*. Evidence of direct impacts is less complete, but the agricultural profile of Belsh confirms its relevance, leading to its designation as **Priority 2**, subject to further stakeholder validation.
- **Wildfire hazard** – identified as an emerging risk, with worsening fire weather indicators. Its ranking remains provisional and will be reviewed with stakeholders in Phase 3.

Phase 2 concludes that Belsh faces multi-sectoral climate risks requiring both immediate and long-term adaptation measures. The results provide more detailed evidence than earlier assessments, strengthen stakeholder perspectives, and enhance legitimacy through participatory engagement.

Looking ahead, Phase 3 will focus on validating risk maps, refining adaptation measures, and embedding them into Belsh's Climate Adaptation Plan. Priority actions will include infrastructure upgrades, improved water management, and capacity-building for municipal institutions and communities. By addressing data gaps and strengthening monitoring frameworks, Belsh will be positioned as a pilot site for climate resilience in Albania and as a model for other rural municipalities facing similar challenges.

1 Introduction

1.1 Background

Belsh Municipality, situated in central Albania about 30 km southwest of Elbasan, covers 196.44 km² and serves as the traditional centre of the Dumre region. Its karst landscape, with rolling hills, semi-natural pastures, and more than 85 lakes, defines both ecological richness and cultural identity. With 17,123 residents (INSTAT, 2023), livelihoods depend on agriculture and livestock, supported by fertile soils that favour cereals, tobacco, vegetables, vineyards, and fruit trees.

The municipality faces both sudden and slow-onset climate pressures. Heavy rain causes runoff, local flooding, erosion, slope instability and damage to roads, while long dry periods and higher temperatures increase crop water demand and strain local water resources. The Phase 2 results also show that fire weather is becoming a significant risk, with the seasonal FWI moving from Very High to Extreme.

EVOLVE-Belsh applies the CLIMAAX Climate Risk Assessment Framework to support local decisions. European risk methods are combined with locally collected data so that the results can be used in municipal planning, emergency preparedness, agriculture, ecosystem protection and the design of adaptation measures.

1.2 Main objectives of the project

Phase II of EVOLVE–Belsh aims to provide a transparent and locally relevant picture of current and future climate risks, laying the groundwork for adaptation planning in Phase III. Building on the foundations of Phase I—where Belsh's climate vulnerabilities and socio-economic dynamics were first mapped—this phase translates knowledge into concrete, evidence-based strategies that are locally owned and actionable.

The core objectives are:

- **Application of CLIMAAX Workflows**: Implementing structured European methodologies in Belsh using local meteorological, GIS, agricultural, and impact data.
- **Future Risk Analysis**: Quantifying how selected hazards and risks evolve under climate change scenarios.
- **Methodological Clarity**: Keeping hazard, exposure, vulnerability, and risk distinct, while documenting assumptions and limitations.
- **Visual and Analytical Outputs**: Producing maps, tables, and GIS layers for discussion with municipal staff, communities, farmers, and technical partners.
- **Sector-Specific Adaptation Planning**: Developing practical strategies for agriculture, infrastructure, tourism, and public health.
- **Capacity and Ownership**: Strengthening institutional capacities and fostering inclusive participation from youth, women, and local enterprises to ensure long-term sustainability.

The CLIMAAX Handbook plays a central role, offering a structured European framework while allowing flexibility to adapt to Belsh's realities. This integration ensures that risk analysis is precise, context-specific, and directly relevant to local challenges. It enhances the identification of hotspots, supports informed decision-making, and builds confidence among institutions and communities.

Ultimately, Phase II transforms risk analysis into practical resilience pathways. Agriculture will benefit from tailored measures against drought and soil degradation; infrastructure and tourism will

be safeguarded from floods and landslides; and public health systems will be better prepared for climate-related stress. By embedding participation and local knowledge at every step, Belsh is positioned not only as a pilot site under the CLIMAAX program but also as a model for other municipalities in Albania, strengthening governance, fostering trust, and ensuring that climate adaptation becomes a shared, inclusive, and forward-looking effort.

1.3 Project team

The EVOLVE–Belsh project team brings together municipal staff and external experts working in close collaboration. Municipal specialists from urban planning, legal affairs, public procurement, and IT ensure that adaptation priorities are embedded in local governance and service delivery. They are joined by INCA's multidisciplinary experts: a climate adaptation specialist guiding risk assessments, a GIS and cartography expert producing vulnerability maps, a data analyst processing socio-economic and environmental datasets, a hydrologist modelling water-related hazards, and an institutional/legal advisor aligning governance frameworks with national and international standards. Together, this integrated team combines local knowledge with scientific expertise, co-creating Belsh's Climate Adaptation Plan and ensuring that strategies are practical, inclusive, and sustainable.

1.4 Outline of the document's structure

This deliverable is organized to present a clear, structured, and evidence-based account of Phase 2 of the EVOLVE–Belsh project. It follows the methodological flow of the CLIMAAX Framework, ensuring coherence between technical analysis, stakeholder engagement, and adaptation planning.

- **Executive Summary** – Provides an overview of the objectives, activities, and key findings of the climate risk assessment, summarizing how Phase 2 builds upon the baseline established in Phase 1.
- **Section 1 – Introduction** – Sets the context by describing Belsh Municipality, defining the main objectives of Phase 2, introducing the project team, and explaining the overall structure and purpose of the report.
- **Section 2 – Climate Risk Assessment (Phase 2)** – Constitutes the core of the deliverable. It details the scoping process, risk exploration, regionalized risk analysis, and the key findings on severity, urgency, resilience capacity, and risk prioritization. It also outlines the monitoring and evaluation framework and the work plan for Phase 3.
- **Section 3 – Conclusions** – Synthesizes the strategic significance of Phase 2, highlighting how the results strengthen local resilience and inform adaptation planning.
- **Section 4 – Progress Evaluation** – Reviews the achievements of Phase 2, assesses methodological improvements, and situates them within the broader CLIMAAX framework.
- **Section 5 – Supporting Documentation** – Includes annexes, maps, visuals, and technical materials that complement the analysis.
- **Section 6 – References** – Lists all data sources, methodologies, and tools used throughout the assessment.

This structure ensures clarity, transparency, and alignment with the CLIMAAX Handbook, while embedding local knowledge and stakeholder participation. It enables the deliverable to function both as a technical report and as a practical guide for advancing climate risk management and adaptation planning in Belsh Municipality.

2 Climate risk assessment – phase 2

This section follows the methodological steps outlined in the CLIMAAX Framework, applying its guiding questions to structure the analysis of climate risks and adaptation planning for Belsh Municipality. Building on the scoping and preliminary assessment conducted in Phase 1, the focus here is on identifying what has changed, refining risk profiles with updated local data, and addressing gaps where information remains limited.

The guiding questions of the **CLIMAAX Handbook** provide a structured framework that ensures both consistency and transparency throughout the assessment. Where sufficient information is available, detailed responses are given; where data gaps remain, these are explicitly noted to highlight areas requiring further investigation. In this way, Phase II strengthens the evidence base, deepens the analytical process, and lays the foundation for actionable adaptation strategies tailored to Belsh's local context.

The assessment follows the **CLIMAAX Framework** and builds directly on the baseline established in Phase I. Future climate conditions are examined across all three risk pathways. However, due to the absence of consistent local projections for population, land use, and assets, exposure and vulnerability are maintained at present-day levels. As a result, the differences observed between time periods reflect the effects of climate change alone, isolating its impact from other socio-economic variables.

2.1 Scoping

The scoping phase of Phase 2 in Belsh defines the objectives of the climate risk analysis, the conditions for its implementation, and the actors who must be engaged to ensure meaningful results. Building on the foundations of Phase 1, this updated scoping reflects new engagement pathways, expanded local datasets, and stronger sectoral interfaces. The focus is on clarifying desired outcomes, situating them within Belsh's evolving socio-economic and environmental context, and identifying stakeholders, experts, and priority groups whose involvement is essential for shaping adaptation strategies. Municipal staff provide local knowledge and continuity, while external experts contribute scientific precision, ensuring that the Climate Adaptation Plan is both technically sound and rooted in community realities. This integrated approach guarantees that the assessment moves beyond vulnerability mapping toward practical, evidence-based measures for resilience, embedding ownership and sustainability into Belsh's climate governance framework.

2.1.1 Objectives

The primary objective of the Climate Risk Assessment (CRA) in Phase 2 for Belsh Municipality is to refine and expand the initial findings from Phase 1 by integrating high-resolution local datasets, newly developed hydraulic models, and stakeholder insights. The purpose is to move beyond baseline risk identification toward designing actionable adaptation strategies that address the municipality's most pressing hazards—floods, extreme rainfall, landslides, and drought. The expected outcome is a locally tailored Climate Adaptation Plan that strengthens resilience in agriculture, infrastructure, tourism, and public health, while embedding ownership within municipal institutions and communities.

In Phase II, the Climate Risk Assessment (CRA) for Belsh faced several challenges. The municipality has limited technical staff, not all community groups participated equally, and it was difficult to bring

together many different types of data. To overcome these issues, a special working group was created in Belsh, supported by experts from INCA. Local workshops also helped gather knowledge from residents, making the results more accurate and trusted.

This phase looks at climate risks that already affect Belsh today and are expected to become more serious by mid-century. The work is done at the municipal level to set priorities for action, not at the level of individual plots or engineering projects. The same municipal boundary is used across all maps and analyses.

There are some important limitations. Local weather records are sometimes old or incomplete, regional climate models are not very detailed, and there are no reliable local projections for population or land use. Past climate impacts are not always well documented, and Belsh does not yet have a fully calibrated flood model. These gaps are clearly noted in the assessment. Climate data is shown at its original resolution, with the 100-meter grid used only for display and to connect with local maps.

By combining scientific data with local knowledge, Phase II improves the quality of risk maps and makes adaptation measures more legitimate. This ensures that climate risk management becomes part of everyday planning and decision-making in Belsh.

2.1.2 Context

Until now, climate-related risks in Belsh have been managed mainly through fragmented, event-based responses and local documentation of damages. Flooding, erosion, landslides, and drought have repeatedly affected villages, agricultural land, olive groves, roads, and water resources, yet these impacts were not connected to a structured climate risk assessment. This reactive approach limited the municipality's ability to anticipate and mitigate growing threats, leaving livelihoods, infrastructure, and public health exposed.

The EVOLVE–Belsh project addresses this gap by introducing a systematic Climate Risk Assessment under the CLIMAAX Framework. The core problem is the absence of integrated climate governance at the local level. While Albania has adopted national strategies such as the National Climate Change Strategy (2019–2030), the Climate Change Law (2020), and the Second National Adaptation Plan (2026–2036), municipal institutions like Belsh continue to face constraints in technical expertise, financial resources, and access to climate-relevant data. Phase 2 seeks to bridge this disconnect by refining risk profiles with high-resolution local datasets, hydraulic models, and stakeholder input, thereby embedding climate adaptation into local planning and decision-making.

Relevant sectors, agriculture, livestock, tourism, infrastructure, and public health, are highly sensitive to climate variability. Droughts threaten crop yields and water availability, floods and erosion damage roads and buildings, and heatwaves pose risks to vulnerable populations. These vulnerabilities are compounded by socio-economic pressures and limited institutional capacity, but external initiatives on biodiversity conservation, water resource management, and rural revitalization provide opportunities for synergy and knowledge exchange.

Phase 1 identified critical data gaps, including missing building footprints, transport infrastructure layers, socio-economic scenarios, and high-resolution flood maps. Phase 2 addresses these limitations by integrating locally generated datasets, community consultations, and alternative modelling approaches. This strengthens hazard and risk mapping, enhances hydrological forecast-

ting systems, and improves early warning mechanisms.

Possible adaptation interventions include upgrading and modernizing infrastructure to reduce flood risk, restoring vegetation cover on erosion-prone slopes, applying nature-based solutions such as afforestation and watershed restoration, introducing water-saving measures for agriculture, and incorporating rainwater collection into urban planning. Together, these measures will feed into Belsh's Local Climate Change Adaptation Plan, ensuring alignment with the National Adaptation Plan and embedding resilience into local and regional development strategies.

2.1.3 Participation and risk ownership

Risk ownership in Belsh involves multiple levels of responsibility, combining institutional mandates with community engagement. The municipality plays a central role in local planning, infrastructure maintenance, emergency coordination, and communication with residents. Depending on the type of risk, other institutions are also engaged, including civil protection structures, agricultural authorities, drainage and irrigation agencies, road maintenance services, and environmental offices. Importantly, risk ownership is not only institutional: farmers, residents, and local businesses are among the first to experience damage when flooding, erosion, or road blockages occur, making community participation essential.

Phase 2 of the EVOLVE–Belsh project has strengthened stakeholder involvement by expanding participation and deepening collaboration across local, regional, and national levels. Building on the mapping conducted in Phase 1, the municipality has worked closely with civil society, technical experts, and community representatives to ensure that climate risk assessment outcomes are inclusive and actionable. Stakeholders who agreed to participate in CLIMAAX-related meetings include municipal departments, the Elbasan Prefecture civil emergencies directorate, the regional environmental office, the Shkumbin River Basin Council, local NGOs, youth and women's groups, farmers' associations, beekeepers, agribusinesses, tourism operators, and academic experts from the University of Elbasan. Their involvement has been formalized through workshops, consultations, and technical sessions coordinated by INCA, the implementing partner.

An organogram (fig. 2-1) has been developed to visualize institutional relationships, responsibilities, and communication flows. This tool clarifies how municipal authorities, regional institutions, civil society, and technical experts interact, and how responsibilities are distributed for risk identification, data collection, and decision-making. It highlights the central role of Belsh Municipality in coordinating local action, supported by INCA's technical expertise and reinforced by community stakeholders who provide local knowledge and monitoring capacity.

Risk ownership in Belsh is primarily regulated through the municipal government, which integrates climate risk into local development plans and emergency response systems. Regional institutions provide oversight and technical support, while vulnerable groups—such as smallholder farmers, pastoralists, older people, and women in rural areas—are represented through civil society organizations and community consultations. Their perspectives ensure that adaptation priorities reflect lived realities and promote equitable resilience.

The acceptable level of risk for Belsh remains low, particularly regarding threats to livelihoods, water security, and public health. Residents have expressed concern about increasing climate variability and strongly support proactive measures to reduce vulnerability. This shared ownership model fosters accountability and sustainability, ensuring that climate adaptation is not only a technical exercise but also a community-driven process.



Figure 2-1 Organogram of key actors and their connection

2.1.4 Application of principles

The Phase 2 analysis for Belsh Municipality has been guided by the principles of the CLIMAAX Framework, social justice and inclusivity, quality and transparency, and the precautionary approach, ensuring that the Climate Adaptation Plan is both technically rigorous and socially equitable.

- **Social justice and inclusivity** are reflected in the attention given to rural communities, smallholder farmers, exposed settlements, access roads, and local livelihoods. Their needs and perspectives are considered to ensure that adaptation measures respond to the realities of those most at risk.
- **Quality and transparency** are ensured through careful data cleaning, the use of traceable sources, keeping the original resolution of climate data, and applying quality-control tables for each workflow. Uncertainties are clearly stated so that decision-makers and citizens understand both the strengths and the limits of the analysis.
- **The precautionary principle** is applied by treating strong projected changes as relevant for decisions, even where detailed impact models are not yet available. The assessment does not claim to provide exact flood depths, precise losses, or parcel-level risks that the data cannot support, but instead focuses on the broader patterns that matter for municipal planning.

By embedding these principles, Phase II strengthens the credibility of the Climate Adaptation Plan, making it scientifically sound, socially fair, transparent, and practical for guiding Belsh's future resilience.

2.1.5 Stakeholder engagement

Stakeholder engagement in Phase II focused primarily on collecting and reviewing local information, especially evidence of past extreme events in Belsh Municipality and sectoral data linked to agriculture and water management. This process confirmed that the selected hazards—flooding, erosion, landslides, and drought—are highly relevant for the local context.

Reported events included damages in villages such as Grekan, Belsh, Kajan, Hyse, Gjolenë, Deshiranë, Dragot, Çestijan, and Fierzë-Kosovë, affecting houses, businesses, olive groves, agricultural land, and road infrastructure. This type of local evidence is critical, as it illustrates how climate-related events are experienced in practice and highlights the vulnerabilities of rural communities.

In February 2026, formal data requests were sent to the Institute of Geosciences, Energy, Water and Environment (IGJEO) for meteorological and hydrological datasets, and to the National Agency for Water Resources Management (AMBU) for information on flood-regulated zones. While official responses from IGJEO were not secured within the project timeframe, the team adapted by using reliable literature sources and online materials relevant to Belsh's territory, ensuring continuity of the analysis and maintaining methodological rigour despite incomplete datasets.

To complement institutional data, a stakeholder consultation was held in May 2026 with municipal staff, village representatives, farmers, youth and women's groups, and local businesses. The consultation reviewed past events, confirmed the locally relevant risk pathways, and discussed their implications for agriculture, infrastructure, and water management. Project goals and intermediate results were communicated through presentations, visual materials, and open discussion. Stakeholders welcomed the structured approach, noting that the CRA provides practical insights and emphasizing the importance of integrating risk information into municipal planning and strengthening early warning mechanisms.

The drought and wildfire analyses, along with future climate projections, were completed after this consultation. The ratings presented in Section 2.4 therefore reflect the project team's technical assessment and will be reviewed with stakeholders at the start of Phase III. This applies particularly to wildfire, where the climate signal is strong but local information on past fires and response capacity remains limited.

Further engagement is planned to validate risk interpretations, assess severity and urgency, and discuss resilience capacity. These outcomes will guide local development plans, improve emergency preparedness, and inform sectoral strategies in agriculture and tourism. Challenges encountered included incomplete datasets, uneven technical capacity among stakeholders, and difficulties in ensuring consistent participation. These were addressed through technical support from INCA, simplified communication materials, and active facilitation during workshops.

This multi-level engagement process demonstrates that even in the absence of complete official datasets, Phase II results remain scientifically robust and socially grounded, fostering ownership and practical application of adaptation measures in Belsh.

2.2 Risk Exploration

Risk exploration begins with a broad screening of the climate-related risks most visible or of greatest concern to stakeholders and the wider public. This step examines the underlying hazards, exposures, and vulnerabilities that shape local impacts, ensuring that the assessment reflects both scientific evidence and community experience. In Belsh Municipality, the process draws on institutional data, local records of past events, and stakeholder consultations to identify priority risks such as flooding, erosion, landslides, and drought.

By combining technical analysis with local knowledge, risk exploration provides the foundation for deeper assessment, helping to clarify which risks are most urgent, which areas and groups are most

exposed, and where adaptation measures should be prioritized. This ensures that subsequent phases of the Climate Risk Assessment are firmly rooted in the realities of Belsh while aligned with the CLIMAAX Framework.

2.2.1 Screen risks (selection of main hazards)

Phase II updates the risk screening for Belsh Municipality by integrating new local datasets and evidence gathered during the project. Rainfall and temperature records from Belsh and nearby stations, documentation of flooding, erosion, and landslides, as well as agricultural and water management information, allowed the analysis to move beyond general hazard identification toward a more localized understanding of risk pathways.

The risk screening draws on local evidence, stakeholder input, climate indicators, and CLIMAAX/Copernicus projections. Three risk pathways were selected because together they capture both sudden and slow onset climate stress and can be analysed with traceable data:

- **Extreme precipitation and local impacts**: intense 24-hour rainfall leading to runoff, flooding, erosion, and landslides affecting farmland, settlements, buildings, roads, and drainage systems.
- **Agricultural drought and heat related water stress**: rising water demand, crop water deficits, yield loss, and economic exposure, interpreted with local irrigation data.
- **Wildfire:** seasonal fire weather index (FWI), burnable vegetation, exposure and vulnerability of people and ecosystems, and the change between current and future conditions.

These pathways were chosen based on available climate data, observed local impacts, and the agricultural profile of the municipality. Together, they provide a structured basis for understanding Belsh's climate risks and for prioritizing adaptation measures in the next phase.

The Copernicus Climate Atlas projections for Albania highlight intensified heat extremes and drought conditions under a 2 °C warming scenario, compounding existing vulnerabilities and demanding proactive resilience planning. Precipitation patterns are expected to shift, with stronger peaks in late spring and summer. Such short, intense downpours often exceed local drainage capacity, leading to flash flooding and infrastructure damage, while contributing little to long term soil moisture recharge. The result is a dual challenge: increased flood risk on the one hand, and persistent water stress on the other.

Phase II therefore retains the hazard portfolio identified in Phase I but advances regionalization through local data integration and methodological adjustments that improve municipal scale decision relevance. The evidence base combines Phase I outputs and CLIMAAX datasets with higher resolution local inputs. Remaining needs include denser wind monitoring, harmonized socio-economic projections at municipal scale, and improved inventories of critical assets and vulnerable groups.

2.2.2 Choose Scenario

For Phase II, all three workflows compare a historical baseline (1976–2005) with the mid-century period 2041–2070 under RCP8.5. This high-emission pathway is used as a stress test for adaptation planning. For extreme precipitation, the change projected by the regional climate model is applied to a baseline derived from local observations; the drought and wildfire workflows compare the historical and future model periods directly.

Future socio-economic scenarios at a suitable resolution are not available for Belsh, so exposure and vulnerability are kept at today's levels unless stated otherwise. The projected changes in risk should therefore be read as the effect of climate change on today's assets, land use and vulnerability, not as a forecast of future development.

Table 2-1. Main Phase 2 risk pathways and scenario design

Risk pathway	*Historical/current basis*	*Future period*	*Scenario*	*Key assumption*
Extreme precipitation	Local observations 1967-1991; model baseline 1976-2005	2041-2070	RCP8.5	Local GEV + CLIMAAX site-specific magnitude/frequency change; exposure held constant
Agricultural drought	1976-2005	2041-2070	RCP8.5	CNRM-CM5 / KNMI-RACMO22E; MapSPAM/GAEZ exposure and vulnerability held constant
Wildfire (FWI)	1976-2005	2041-2070	RCP8.5	Seasonal FWI multi-model mean; EFFIS exposure/vulnerability held constant

Table 2-2. Meteorological stations used in the local climate assessment

Station	*Latitude*	*Longitude*	*Elevation (m)*	*Data*	*Use*
Belsh	40.981123	19.890224	155	Rainfall + temperature	Target/reference station
Cerrik	41.016212	19.965165	80	Rainfall + temperature	Surrounding station
Grekan	40.932877	19.948501	180	Rainfall + temperature	Surrounding station
Lushnje	40.949540	19.698500	19	Rainfall + temperature	Surrounding station
Peqin	41.049542	19.748497	53	Rainfall + temperature	Surrounding station
Devoll Kozare	40.832798	19.912568	24	Rainfall only	Supporting source; not used in final rainfall interpolation

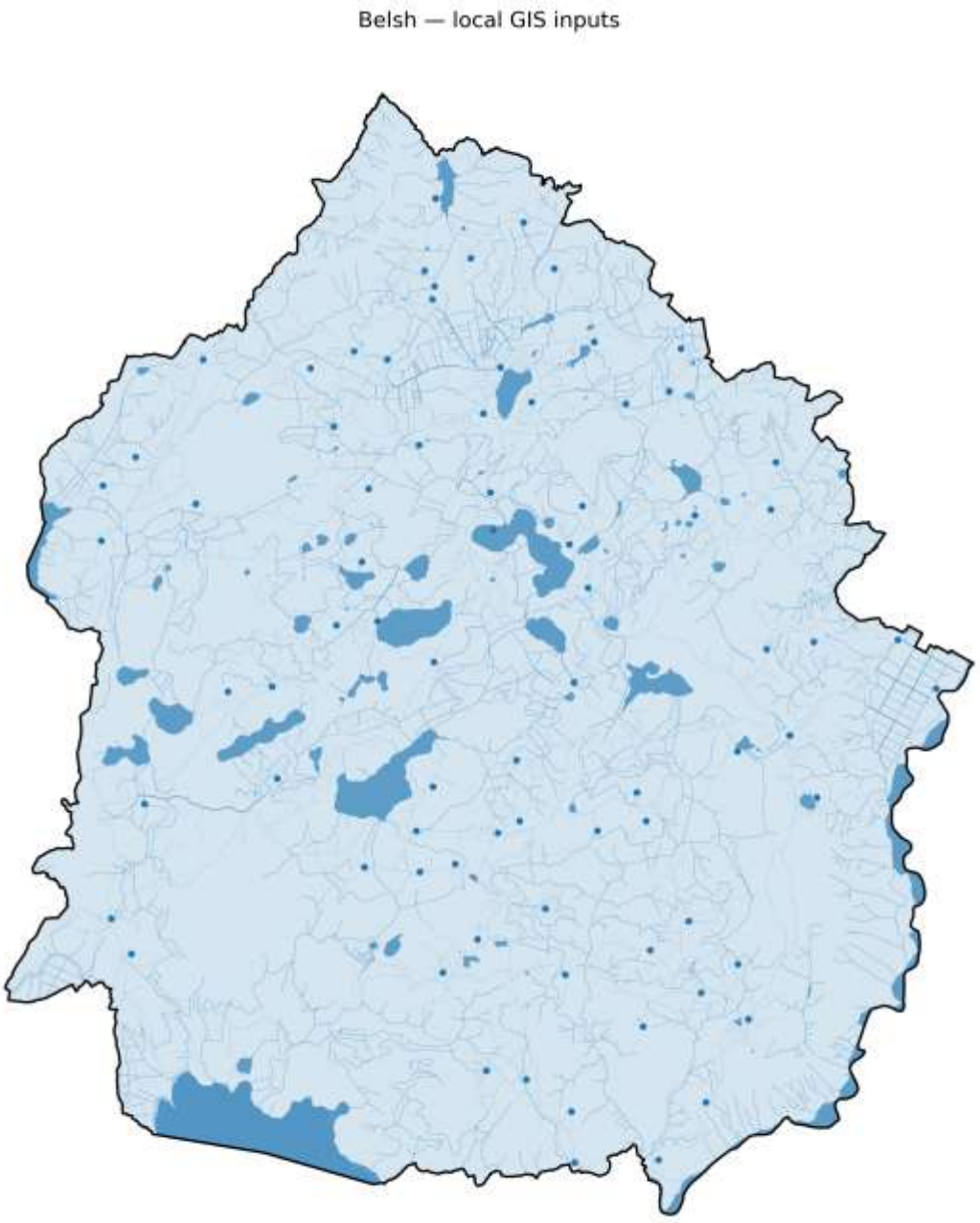


Figure 2-2 Local GIS inputs used for Phase 2 regionalization, including municipal boundary, land-use planning, hydrography, settlements, buildings and transport context

2.3 Regionalized Risk Analysis

In Phase 2, each risk workflow was tailored to the Belsh context, using the structure of the CLIMAAX framework together with the local datasets available. The physical meaning and resolution of the climate data were preserved, while municipal GIS layers and sectoral information were applied to interpret results in a way that reflects local realities. Where outputs are displayed on the 100-meter local grid, each cell represents either the nearest climate-model value or is overlaid with land-use information. No statistical downscaling was applied, ensuring that the analysis remains transparent and traceable to the original data sources.

2.3.1 Hazard #1 - Extreme precipitation and rainfall-related local impacts

This pathway treats extreme rainfall as the driver and looks at what it means for local flooding and runoff, erosion and landslides. It is a regional screening of rainfall-related risk, not a hydraulic flood model: it shows where existing assets face increasing extreme rainfall, but it does not estimate flood depth, flow velocity or damage to individual parcels.

Table 2-3. Data overview - extreme precipitation workflow

Component	*Datasets and outputs*
Hazard data	Daily precipitation observations; annual maximum 1-day rainfall; local GEV return levels; CLIMAAX current/future 24-hour rainfall thresholds
Exposure data	6,522 buildings; 78 settlements; 463.84 km mapped roads/tracks; PPV land-use systems; 1,666 streams/channels; 109 water bodies
Vulnerability/context	Historical local impact records; agricultural dependence; drainage/hydrography context; terrain context
Risk/impact outputs	RP2-RP100 current/future rainfall; future return-period shift; rainfall at exposed assets; PPV exposure screening; historical-impact overlay

2.3.1.1 Hazard assessment

Annual maximum 1-day rainfall was derived from the cleaned daily records of the five stations for the common period 1967–1991, with values coded −99 treated as missing. A Generalized Extreme Value distribution was fitted to each station to obtain the 2-, 5-, 10-, 25-, 50- and 100-year return levels. No elevation correction was applied, since rainfall does not follow a fixed lapse rate with altitude.

The future change comes from the CLIMAAX extreme-precipitation analysis for Belsh (1976–2005 vs 2041–2070, RCP8.5, ICHEC-EC-EARTH / KNMI-RACMO22E). The relative change for each return period was applied to the station-based values, so the local pattern comes from observations and the size of the change from the climate model.

Table 2-4. Extreme precipitation returns levels and future changes

Current RP (years)	*Current 24h rainfall (mm)*	*Future 24h rainfall at same RP (mm)*	*Magnitude change*	*Future RP of current magnitude (years)*
2	55.17	63.35	+14.83%	~2
5	77.14	95.46	+23.75%	~3
10	97.61	126.93	+30.03%	~5
25	132.97	184.07	+38.43%	~8
50	168.39	244.18	+45.01%	~13
100	213.85	324.72	+51.85%	~22

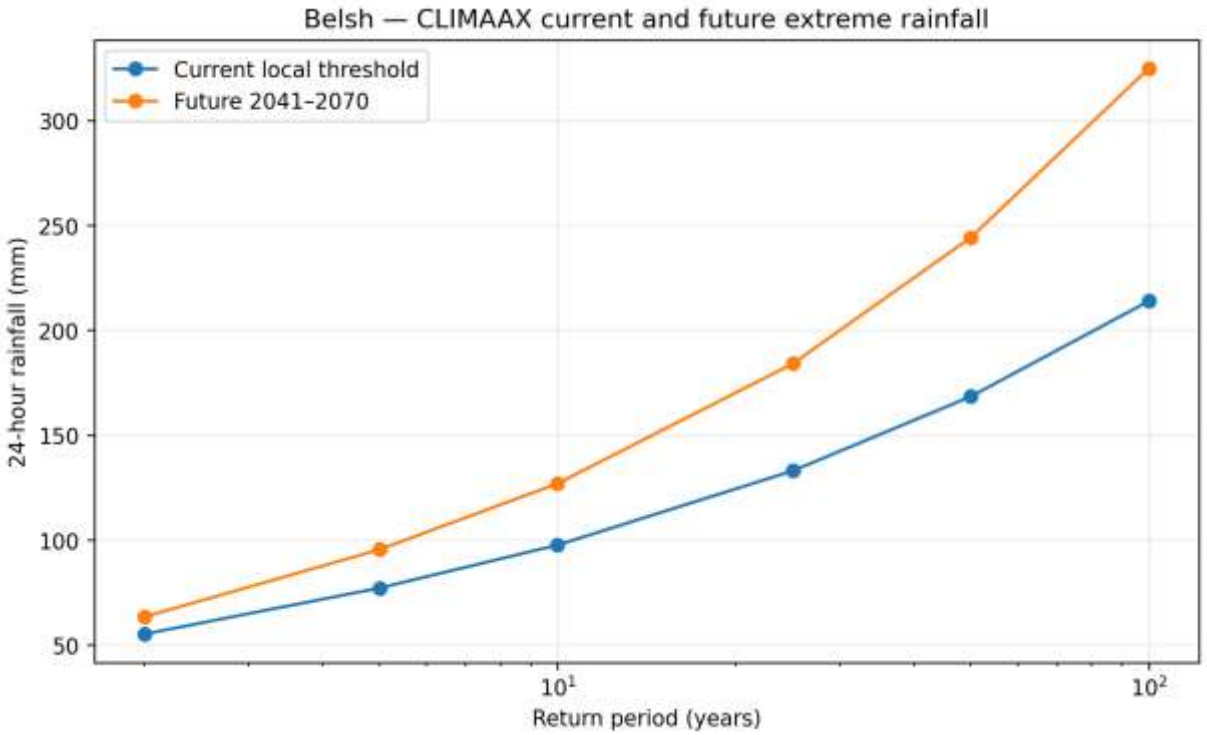


Figure 2-3 Current and future 24-hour precipitation return levels for Belsh. The future scenario shows both larger event magnitudes and a marked reduction in the recurrence interval of present-day extremes

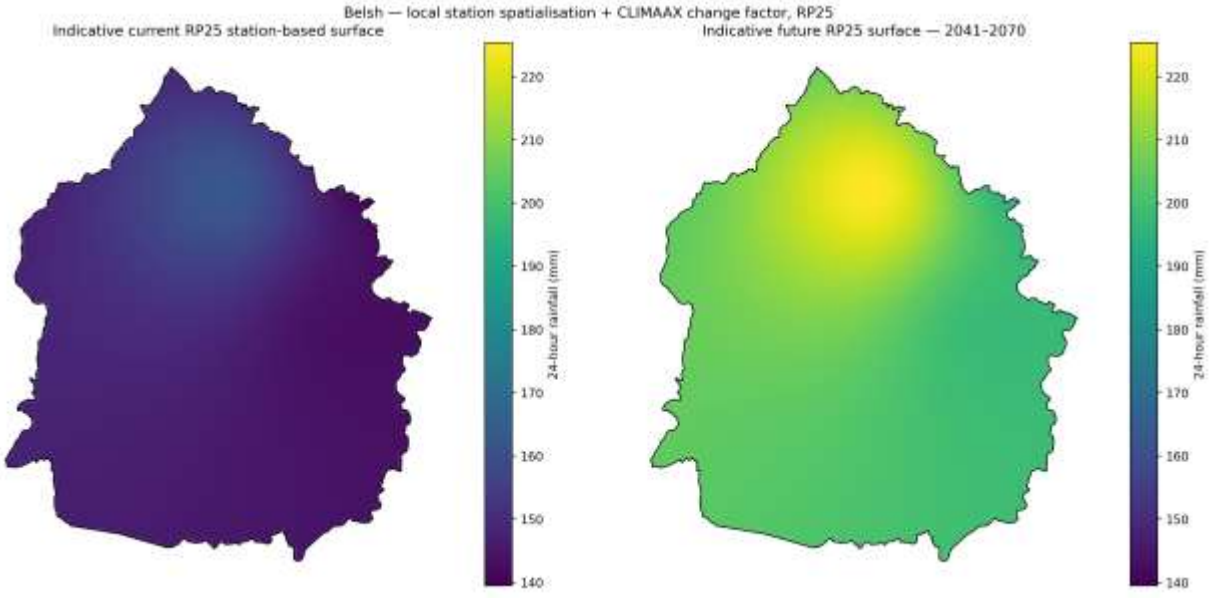


Figure 2-4 Indicative current and future RP25 24-hour rainfall surfaces. The local station pattern is preserved and multiplied by the CLIMAAX return-period-specific future change factor; the surface is not a hydraulic inundation map

2.3.1.2 Exposure, Vulnerability and Risk assessment

The risk assessment for extreme rainfall in Belsh Municipality combines rainfall indicators with the documented history of local impacts. Evidence confirms that heavy rainfall has repeatedly caused significant damage across the territory. The 2026 flooding episode in Belsh, Kajan, and Grekan was

the most severe, affecting approximately 10.2 hectares, damaging 17 structures, impacting arable land, and destroying about 250 meters of secondary road infrastructure, with reported economic losses of around 11 million ALL. Other recorded events highlight damages to road axes, olive groves, agricultural land, and residential buildings.

Exposure is extensive. The municipal inventory includes 6,522 buildings, 78 settlements, and 464 km of roads and tracks. According to the PPV, land use comprises about 13,708 ha of agricultural land, 3,179 ha of natural land, 1,228 ha of water, 878 ha of urban land, and 179 ha of infrastructure. At these exposed locations, future 10-year rainfall events are projected to average around 130–131 mm, roughly 30% higher than today. For 25- and 50-year events, the increase is estimated at 38% and 45%. While not every asset will be directly flooded, the rainfall driving runoff, drainage overload, erosion, and local flooding is expected to intensify significantly.

Vulnerability is closely tied to Belsh's agricultural profile. Field crops, forage crops, vegetables, olive groves, and vineyards form a substantial part of land use and the rural economy. Extreme rainfall therefore represents not only a physical hazard for roads and buildings but also a serious threat to productive land and long-term agricultural assets. During intense rainfall, agricultural areas may suffer from surface runoff, temporary flooding, soil erosion, or sediment deposition. Olive groves and vineyards are particularly vulnerable, as they represent long-term investments for farmers; damage to these areas can have lasting consequences, especially where erosion or slope instability reduces land productivity.

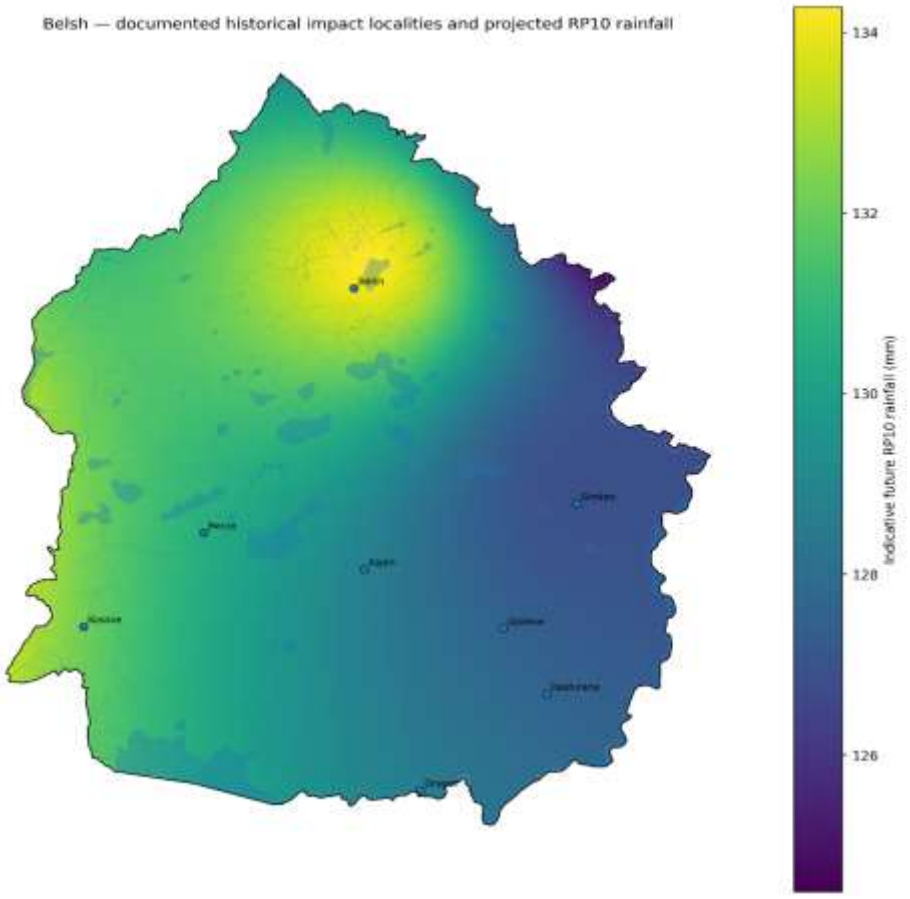


Figure 2-5 Documented historical impact localities overlaid on the projected future RP10 rainfall surface. The map supports local risk interpretation but does not assign causal flood depth or damage to individual locations

Risk emerges from the combination of hazard (extreme rainfall), exposure (the large stock of assets and land uses), and vulnerability (sensitivity of agriculture and infrastructure). This makes extreme rainfall a priority risk pathway for Belsh, requiring adaptation measures that protect agricultural land, rural infrastructure, and long-term community assets.

Limitation: This assessment focuses on **rainfall-related risk**, not on hydraulic flood modelling. No calibrated flood model or depth-damage function was applied. The workflow reports the **extreme-rainfall hazard** and an **exposure screening**, supported by historical impact records, terrain characteristics, and drainage information. The future maps illustrate **rainfall intensity**, not flood depth or inundation extent.

2.3.2 Hazard #2 - Meteorological drought and heat-related water stress

Agricultural drought and heat-related water stress was identified as the second major hazard for Belsh Municipality due to the sensitivity of its farmland, olive groves, vineyards, and local water resources. Unlike extreme rainfall, which produces immediate damage, drought and heat stress evolve gradually, undermining soil moisture, crop yields, and water availability over time.

The assessment concentrated on meteorological indicators. Precipitation data were analyzed to capture dry days, consecutive dry spells, and summer rainfall, while temperature records were used

to evaluate annual and seasonal thermal conditions. This dual approach was essential, since higher temperatures intensify evapotranspiration and water stress even when annual rainfall totals do not appear critically low.

Temperature datasets were drawn from stations in Belsh, Cërrik, Grekan, Lushnje, and Peqin, while Devoll Kozare was excluded due to missing mean temperature records.

The core of the work applied the CLIMAAX Agricultural Drought workflow, linking atmospheric water demand, crop water requirements, rainfed water availability, potential yield loss, and economic exposure. The analysis was anchored in the PPV agricultural land inventory and interpreted with local irrigation data, ensuring that results reflect both the physical hazard and the practical vulnerabilities of Belsh's farming systems.

Table 2-2 Data overview workflow #2

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
EURO-CORDEX historical 1976-2005 and future 2041-2070 RCP8.5; FAO Penman-Monteith ET0; crop-specific ETc and rainfed ETa; Doorenbos yield-response logic	GAEZ v5 irrigated-cropland share (2015) as spatial proxy; local irrigation network and irrigated-area context	PPV Agricultural land (13,707.99 ha); MapSPAM 2020 V2r2 crop production; GAEZ v5 aggregated crop value	ET0, ETc, ETa, ET deficit, potential yield loss, staple-crop revenue-loss screening; supporting tomato non-staple test

2.3.2.1 Hazard assessment

Reference evapotranspiration (ET0) is calculated with the FAO Penman–Monteith method. Crop

evapotranspiration (ETc) is the water a crop needs without stress; rainfed actual evapotranspiration (ETa) is what the crop can actually use from rainfall and soil water. The difference (ETc − ETa) is converted to potential yield loss with the FAO yield-response approach used in the CLIMAAX workflow.

Table 2-3 Agricultural drought hazard results on PPV Agricultural land

Indicator	*Historical 1976-2005*	*Future 2041-2070 RCP8.5*	*Change*	*Relative change where meaningful*
ET0 - reference crop	938.23 mm	1,034.76 mm	+96.53 mm	+10.3%
Maize ETc	343.69 mm	382.53 mm	+38.84 mm	+11.3%
Maize ETa	331.93 mm	340.25 mm	+8.31 mm	+2.5%
Maize ET deficit	11.76 mm	42.28 mm	+30.52 mm	-
Maize potential yield loss	5.11%	16.55%	+11.44 percentage points	-
Wheat potential yield loss	0.00%	0.00%	0.00	-
Tomato potential yield loss	0.00%	0.00%	0.00	-

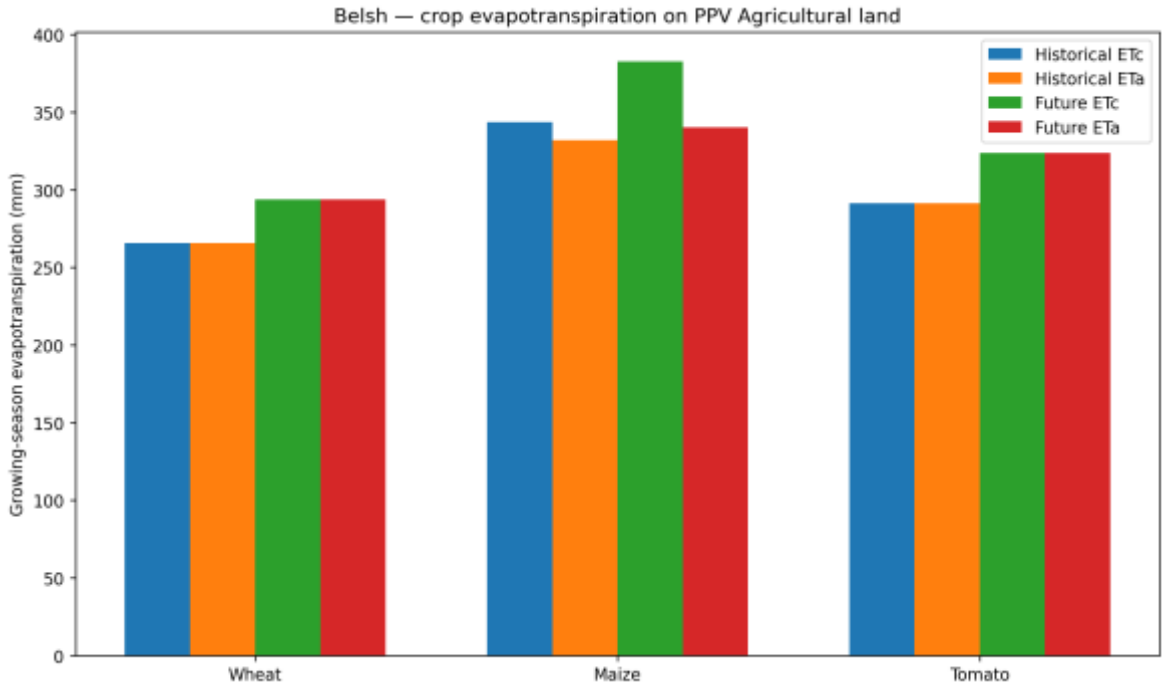


Figure 2-6 Crop evapotranspiration (ETc) and rainfed actual evapotranspiration (ETa) on PPV Agricultural land. The widening maize ETc-ETa gap is the main modelled drought signal.

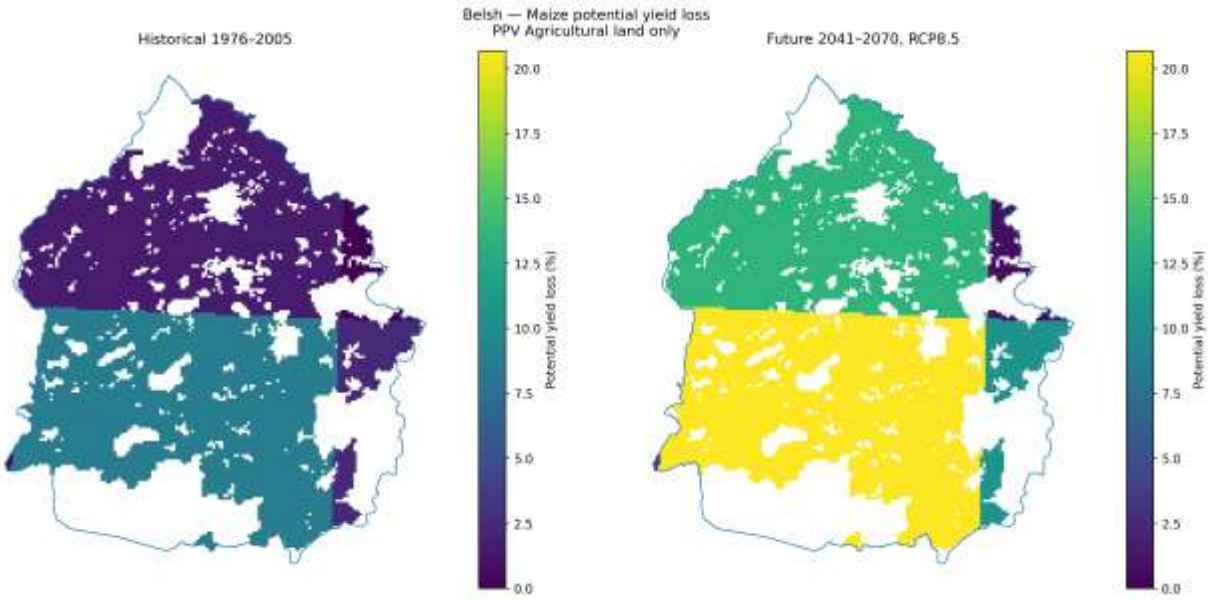


Figure 2-7 Modelled maize potential yield loss on PPV Agricultural land: historical 1976-2005 versus future 2041-2070 under RCP8.5. The block pattern reflects allocation from coarse EURO-CORDEX source cells, not 100 m climate resolution

Maize shows the clearest signal. Evapotranspiration and maize water demand increase considerably, while the water available to a rainfed crop hardly changes, so the deficit and the potential yield loss grow. Wheat and tomato show no simulated loss with the model and crop calendars used. This is a result of the configuration (wheat grows mainly in the wet season, and the default tomato calendar does not match local practice) and should not be read as evidence that these crops are unaffected by drought.

2.3.2.2 Exposure, Vulnerability and Risk assessment

The assessment integrates indicators of dry periods, summer rainfall, and temperature conditions with Belsh Municipality's exposure profile. The most affected elements are agricultural land, olive groves, vineyards, rural settlements, and local water resources.

Local agricultural datasets were analysed to capture exposure and vulnerability. These include field and forage crops, vegetables, fruit trees, olives, grapes, greenhouse areas, irrigation infrastructure, and drainage systems—all directly dependent on seasonal rainfall and water availability.

Belsh's agricultural structure highlights cereals, forage crops, vegetables, olives, and vineyards as the backbone of production. Forage crops dominate in area, while olives and grapes represent long-term investments that are highly vulnerable to repeated droughts and rising summer temperatures, with cumulative impacts on productivity.

Risk quantification applied the staple-crop workflow, combining yield loss estimates with MapSPAM 2020 production data and GAEZ v5 crop values to calculate potential income losses under non-irrigated conditions. The GAEZ share of irrigated cropland served as the vulnerability indicator. Exposure and vulnerability were held constant between periods, so observed changes reflect climate drivers alone.

Table 2-4 Staple-crop drought-risk results on PPV Agricultural land

Crop	Economic-data coverage	Historical yield loss	Future yield loss	Historical risk screening (kEUR/source cell)	Future risk screening (kEUR/source cell)
Wheat	94.15%	0.00%	0.00%	0.00	0.00
Maize	94.15%	5.28%	16.91%	58.11	184.88

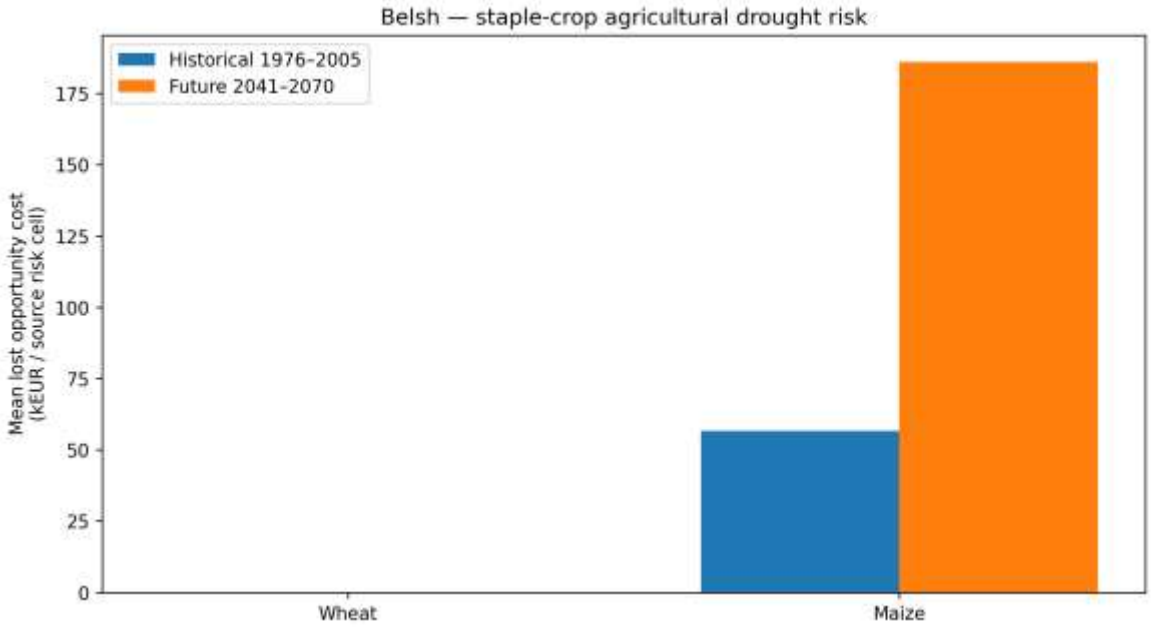


Figure 2-8 Staple-crop drought-risk screening: historical versus future. Values are per climate-model cell and are not a municipal total.

The irrigation network of Belsh Municipality extends for about 30 km, mainly through primary and secondary canals. The irrigated area has declined from approximately 100 hectares in 2012 to about 60 hectares in 2023, representing only 0.4% of agricultural land. In contrast, the GAEZ dataset reports a much higher share (around 14%), reflecting differences in source, year, resolution, and definition. Within the CLIMAAX workflow, GAEZ is used as the spatial vulnerability layer, but local figures indicate that nearly all farmland in Belsh is rainfed. This suggests that drought risk is more likely to be underestimated than overestimated.

Narrative information highlights the lakes of Çestijan, Çerragë, and Civilë as key water intake sources for irrigation. Their role underscores the importance of local water bodies in sustaining agricultural activity and demonstrates why drought, heat, and water availability must be assessed together in Belsh's climate risk analysis.

The economic values presented for maize represent **area-weighted figures per climate-model cell**, not municipal loss totals. On the 100 m maps, each grid cell simply displays the value of its corresponding model cell for visualization purposes. These values therefore illustrate the **spatial distribution of potential losses**, but they should not be aggregated to estimate overall municipal

losses. Their role in the analysis is to highlight relative risk patterns across the territory, rather than to provide a direct financial total for Belsh Municipality.

2.3.3 Hazard #3 - Wildfire

The third hazard pathway is assessed through the CLIMAAX wildfire workflow, which applies the Fire Weather Index (FWI) as its primary indicator. The FWI measures the influence of weather and fuel-moisture conditions that create favorable environments for fire occurrence. It does not predict ignition events, burnt area, or fire spread; rather, it identifies periods when the landscape is more susceptible to wildfire due to atmospheric stress.

In the Belsh context, this indicator is particularly relevant because large areas of agricultural land, olive groves, vineyards, and natural vegetation are exposed to seasonal heat and dryness. Rural settlements and local water resources add to the vulnerability profile, as they can be directly affected by fire or indirectly impacted through reduced ecosystem services.

By combining FWI outputs with the municipality's exposure data, the analysis highlights where climatic conditions overlap with sensitive assets, creating potential risk zones. This approach ensures that wildfire hazard is interpreted not only as a meteorological signal but also in terms of its implications for agriculture, rural infrastructure, and community safety.

Table 2-5 Data overview - wildfire workflow

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*	*Danger/fuel data*
Copernicus fire-danger indicators / EURO-CORDEX seasonal FWI; historical 1976-2005; future 2041-2070 RCP8.5; multi-model mean	EFFIS ecosystem irreplaceability and restoration-cost index	EFFIS WUI share and population density; protected-area fraction; local PPV and building overlay for context	Official CLIMAAX Pareto front; human-focused and ecological-focused Pareto views; supplementary Danger x Exposure x Vulnerability screening score	EFFIS burnable-vegetation fraction combined with seasonal FWI

2.3.3.1 Hazard assessment

Seasonal Fire Weather Index (FWI) values for the periods 1976–2005 and 2041–2070 (RCP8.5 scenario) were obtained from the Copernicus fire-danger indicator dataset. This dataset has a spatial resolution of approximately 0.11° (11–12 km), which provides regional-scale information on fire-favorable weather and fuel-moisture conditions.

For the local analysis, each 100 m grid cell was assigned the value of the nearest climate-model cell. This procedure produces overlay maps that allow visualization of wildfire hazard at municipal scale, but it does not represent statistical downscaling. The maps therefore illustrate how broader climate signals translate into local conditions, highlighting areas where seasonal fire danger may overlap with sensitive land uses.

The dataset was used to compare baseline conditions (1976–2005) with future projections (2041–2070), enabling the identification of shifts in seasonal fire danger under a high-emission scenario. This approach provides insight into the relative change in hazard intensity and distribution, rather

than predicting ignition events, burnt area, or fire spread.

By integrating FWI outputs with Belsh's exposure profile—agricultural land, olive groves, vineyards, vegetation, and rural settlements—the assessment highlights where climatic drivers of wildfire risk are most likely to affect local assets.

Table 2-6 Wildfire hazard and risk results

Indicator	Historical	Future 2041-2070 RCP8.5	Change	Interpretation
Area-weighted seasonal FWI	44.79	53.08	+8.28	+18.59%
Dominant fire-danger class	Very High	Extreme	Class shift	-
Area-weighted wildfire danger index	0.300	0.506	+0.206	+68.7%
Supplementary H x E x V risk score	0.00384	0.00554	+0.00171	+44.5%
Official Pareto high-risk area	2,134.02 ha	2,134.02 ha	No area change	11.9% of analysed land area

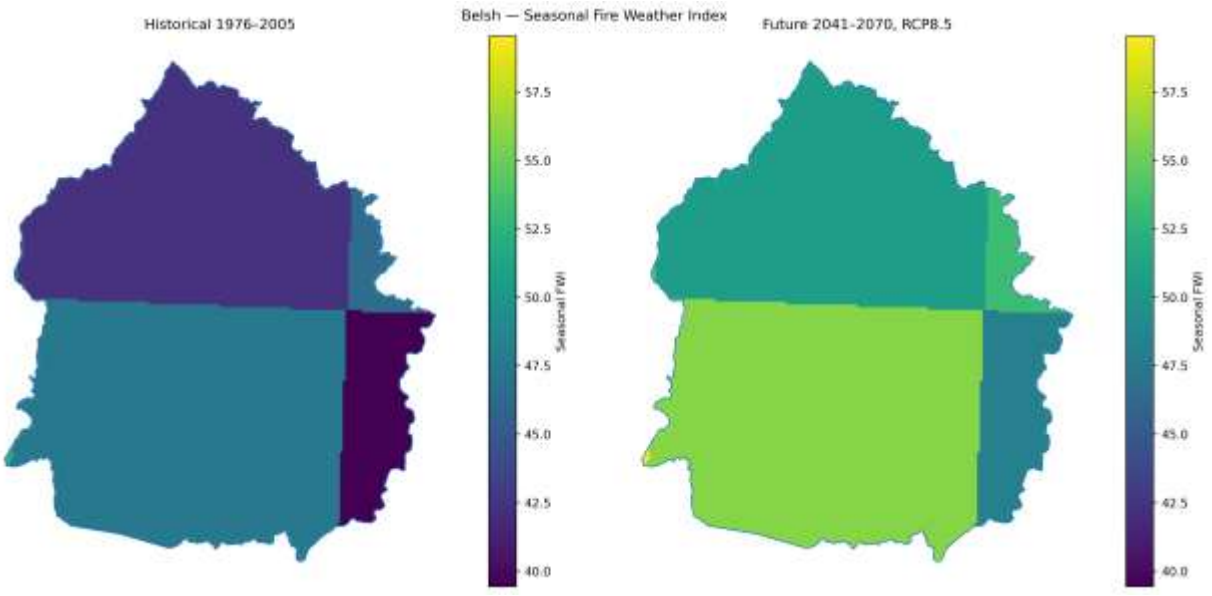


Figure 2-9 Seasonal Fire Weather Index: historical 1976-2005 versus future 2041-2070 under RCP8.5. The dominant class shifts from Very High to Extreme

The optional daily indicator of fire-season length could not be calculated, because the daily data are no longer provided through the Climate Data Store. This does not affect the seasonal FWI or the CLIMAAX risk assessment, which is based on seasonal FWI.

2.3.3.2 Exposure, vulnerability and risk assessment

In the CLIMAAX risk step, seasonal FWI is combined with burnable vegetation to give a danger index,

which is then assessed together with the EFFIS exposure and vulnerability indicators through a Pareto analysis. The default analysis uses danger, wildland–urban interface, protected areas, ecosystem irreplaceability and restoration cost; population density is used in an additional view focused on people.

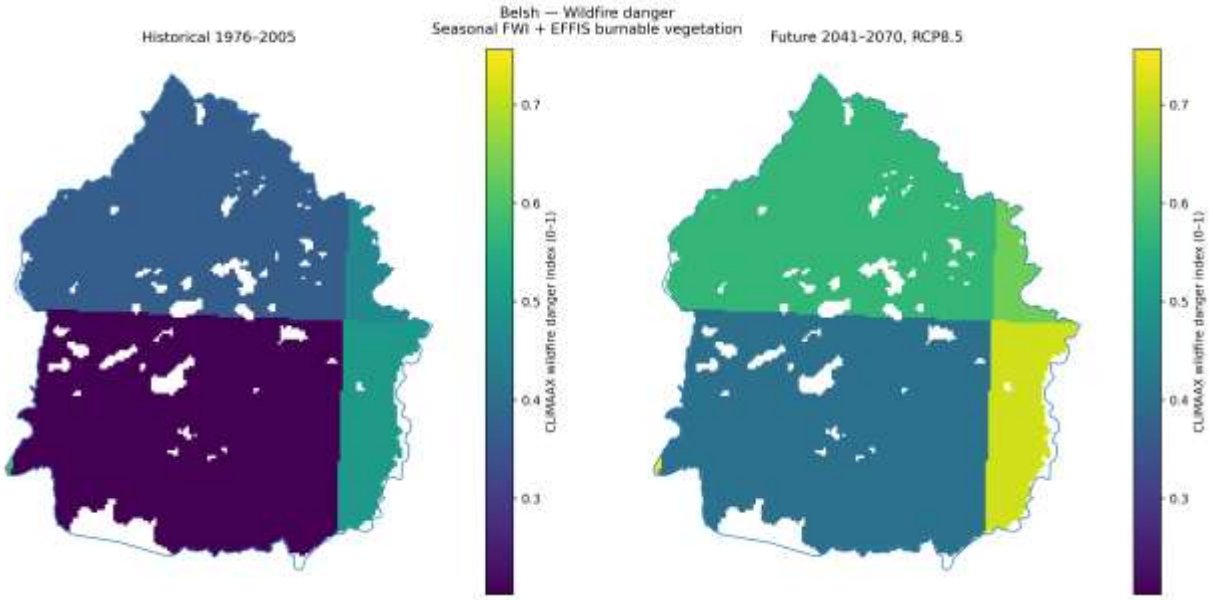


Figure 2-10 Wildfire danger index: historical versus future. The index combines common-scale seasonal FWI and EFFIS burnable vegetation.

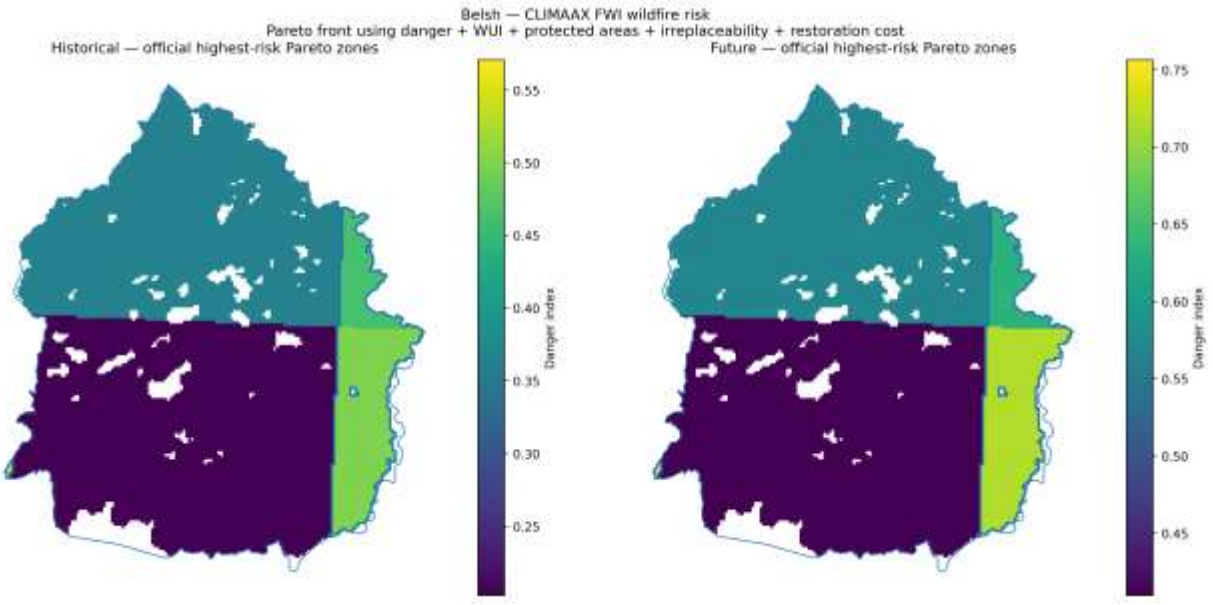


Figure 2-11 Official CLIMAAX Pareto wildfire risk: historical versus future. Three of six Belsh source cells lie on the highest-risk Pareto front in both periods.

Three of the six model cells covering Belsh are in the highest-risk Pareto group in both periods, covering about 2,134 ha. This does not mean that the risk stays the same. The Pareto analysis ranks cells relative to each other, so the same cells remain at the top while their hazard increases: the danger index rises by about 69% and the supplementary risk score by about 45%.

By land-use system, natural land has the highest supplementary risk score, followed by urban and agricultural land. Of the highest-risk Pareto area, about 1,109 ha is agricultural, 952 ha natural and

73 ha urban. These are the areas where fire prevention and preparedness should be discussed first.

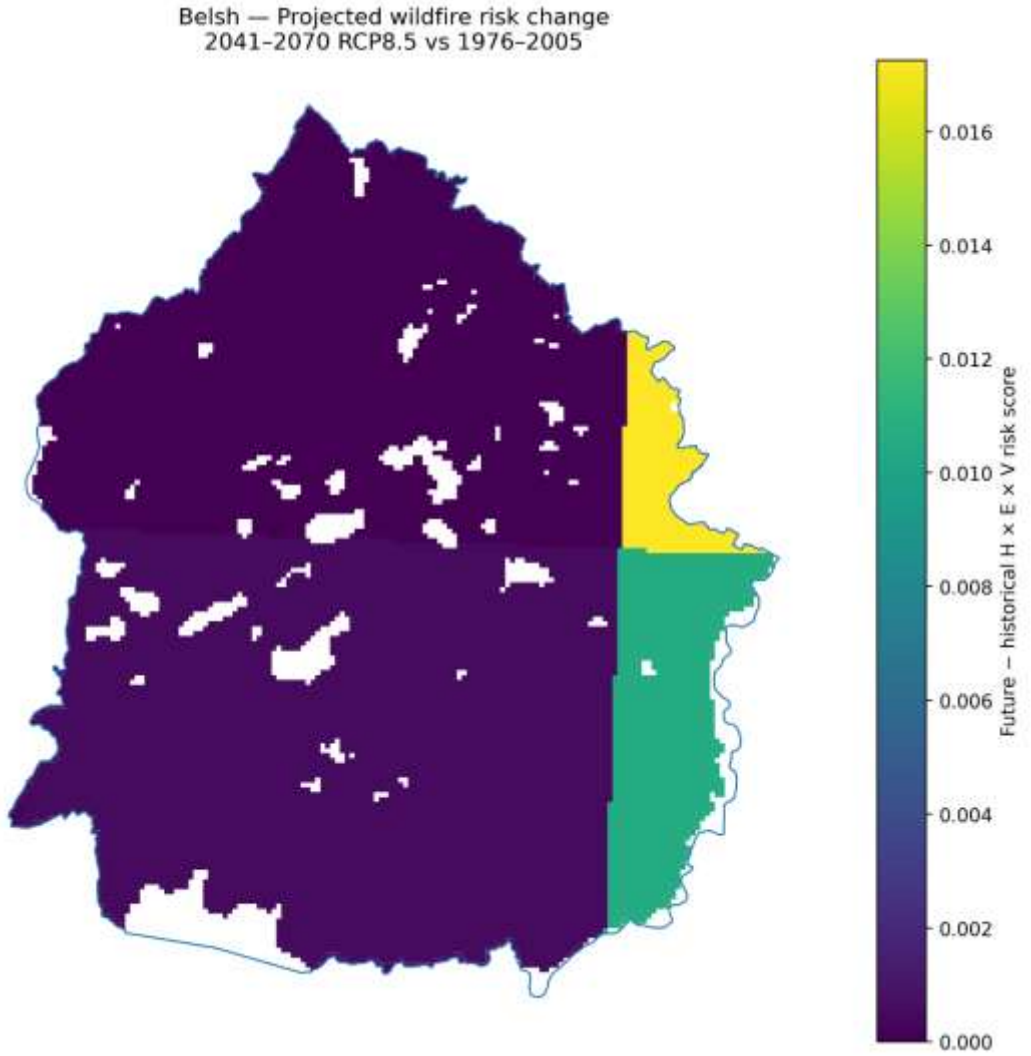


Figure 2-12 Supplementary wildfire Danger x Exposure x Vulnerability risk change. The metric is included for transparent current-future comparison and does not replace the official CLIMAAX Pareto result.

Seasonal Fire Weather Index (FWI) values for 1976–2005 and 2041–2070 (RCP8.5 scenario) were obtained from the Copernicus fire-danger indicator dataset, with a spatial resolution of approximately 0.11° (11–12 km). For local visualization, each 100 m grid cell was assigned the value of the nearest model cell, producing overlay maps that illustrate fire-favourable conditions at municipal scale. This procedure does not represent statistical downscaling, but rather a way to display regional climate signals in a local context.

At the six model cells covering Belsh, the **EFFIS layers for protected areas and ecosystem irreplaceability contained no values**, which were therefore treated as zero in the supplementary scoring. As a result, all wildfire outputs should be interpreted as **screening results at the scale of the model cells**, not as predictions of ignition, burnt area, or fire behaviour at specific sites. The maps highlight relative hazard conditions and their overlap with sensitive land uses, providing a basis for exposure and vulnerability analysis rather than site-specific forecasts.

2.3.4 Additional assessments based on local models and data

Several local analyses were undertaken to strengthen and harmonize the interpretation of the three

hazard workflows. Rainfall and temperature indicators from nearby stations were cleaned and standardized; rainfall was interpolated using IDW without elevation correction, while temperature was adjusted with a lapse-rate correction derived from the DEM. The PPV land-use layer was consolidated into five categories—agricultural, natural, water, urban, and infrastructure systems, and applied consistently across all workflows to ensure comparability.

The integrated results highlight the dual exposure of agriculture: more intense rainfall increases runoff and erosion, while higher evapotranspiration and water deficits intensify drought stress. *Natural and semi-natural land plays a central role in wildfire hazard, while rural roads, settlements, and drainage systems emerge as critical exposure points for extreme rainfall*.

This cross-risk perspective shows that multiple hazards converge on overlapping assets, underscoring the value of measures that address several risks simultaneously, such as soil and water conservation, resilient infrastructure, and integrated land-management practices.

2.4 Key Risk Assessment Findings

The Key Risk Assessment represents the transition from hazard description to prioritization of risks that require greater attention in the next phase of the project. It integrates the outputs of the climate analysis, historical impact records, and the first interpretation of exposure and vulnerability in Belsh Municipality.

Risks are evaluated against three criteria: severity, urgency, and response capacity, as displayed in the evaluation dashboard. This structured approach ensures that findings are evidence-based while also facilitating engagement with stakeholders, experts, and priority groups.

In Belsh, the strongest evidence relates to extreme rainfall, with past events causing damage to buildings, agricultural land, olive groves, and road infrastructure. This risk is therefore prioritized as the most urgent. Agricultural drought and heat-related water stress remain highly relevant, but the available evidence of direct impacts is less complete and requires further validation through local consultation.

2.4.1 Mode of engagement for participation

The Key Risk Assessment process began with the stakeholder consultation held in May 2026, which provided the first participatory input on climate hazards and their local impacts. This consultation was combined with the project team's interpretation of Phase 2 results, ensuring that both technical evidence and community perspectives were reflected.

At this stage, the focus was on identifying documented risks in the territory and determining which sectors appeared most exposed. Local records of past events proved particularly valuable, showing that flooding, erosion, and landslide impacts had already affected buildings, agricultural land, olive groves, and road infrastructure. Stakeholders confirmed the relevance of these hazards and emphasized the need to prioritize them in the risk assessment.

The analyses of drought and wildfire were completed after the consultation. Their ratings therefore represent the team's technical assessment and will be reviewed with stakeholders at the start of Phase 3. This ensures that the evaluation remains iterative, with new evidence validated through local dialogue.

This participatory approach provided confirmation of documented risks and guidance on areas needing additional local validation, strengthening the credibility of the assessment and laying the

foundation for inclusive decision-making in the next phase.

2.4.2 Gather output from Risk Analysis step

The Key Risk Assessment builds directly on the technical outputs generated during the Risk Analysis step, which provide the foundation for evaluating severity, urgency, and resilience capacity. These outputs ensure that the assessment is firmly anchored in local evidence and spatial context.

The datasets and indicators applied include:

- **Climate datasets** from Belsh and surrounding meteorological stations, harmonized for consistency.
- **Rainfall indicators** (annual totals, summer rainfall, maximum 1-day rainfall, heavy rainfall days) to capture seasonal and extreme precipitation.
- **Dry-condition indicators** (number of dry days, longest dry spell) to assess drought stress and water scarcity.
- **Temperature indicators** (annual and summer mean) to evaluate heat stress and long-term warming.
- **Geospatial reference data** (station coordinates, elevation, municipal boundaries, DEM) to support mapping and spatial interpretation.
- **Historical extreme event records** documenting flooding, erosion, and landslides, linked to affected assets and sectors.
- **Agricultural and water-management datasets** showing how climate impacts intersect with land use, irrigation, and resource management.
- **Visual outputs** (graphs, maps, interpolation-ready tables, GeoTIFF/PNG layers) prepared for reporting and GIS integration, ensuring accessibility for both technical analysis and stakeholder engagement.

In addition, the assessment incorporates projected changes in extreme rainfall, the local record of damaging events, and the results of the drought and wildfire workflows—including evapotranspiration, yield loss, economic indicators, Fire Weather Index, danger index, and Pareto zones. These are combined with PPV land-use data, building and road layers, irrigation information, and documented limitations, creating a comprehensive evidence base for structured risk evaluation.

2.4.3 Assess Severity

The severity of climate risks in Belsh Municipality has been assessed according to the four categories defined in the Key Risk Assessment Protocol (*limited, moderate, substantial, critical*). The evaluation combines historical records, climate indicators, modelled projections, and stakeholder perspectives to capture both current and future conditions.

☞ **Extreme rainfall, local flooding, erosion, and landslide-related impacts**

Severity is rated **Substantial** for both the current and future periods. Documented events, such as the 2026 flood in Belsh, Kajan, and Grekan, caused damage across multiple sectors—houses, businesses, agricultural land, and road infrastructure—with reported losses of about 11 million ALL. Projections show 24-hour rainfall increasing by 30–52% for 10- to 100-year events. The risk is not rated Critical, as no hydraulic flood model or calibrated damage model is available, but the persistence and multi-sectoral nature of impacts confirm its priority status.

☞ **Meteorological drought and heat-related water stress**

Severity is assessed as **Moderate today and Substantial in the future**. Current evidence highlights the sensitivity of olives, vineyards, vegetables, and forage crops to water availability. Modelled maize yield loss increases from about 5% to 17%, while the economic indicator rises threefold under future scenarios. Although direct records of drought damage are less complete than for rainfall hazards, projections indicate growing stress on agriculture and water resources, with potential cascading effects if adaptation measures are not implemented.

- **Wildfire hazard**

Severity is rated **Moderate today and Substantial in the future**. Fire weather conditions move into the Extreme class and the danger index rises sharply. However, the absence of a local record of wildfire impacts prevents assigning a higher current rating. Future projections suggest increasing exposure of natural and semi-natural land, reinforcing the need for preventive measures.

- **Stakeholder perspectives and institutional capacity**

Consultations confirmed the strong evidence for extreme rainfall impacts and emphasized the need to validate drought and heat-related risks more thoroughly. Vulnerable groups highlighted the multi-sectoral nature of flooding, while agricultural representatives stressed the importance of water management. Decision-makers are increasingly aware of climate risks, but further training and capacity-building are required to ensure that severity assessments are fully integrated into planning.

2.4.4 Assess Urgency

The urgency of climate risks in Belsh Municipality has been assessed according to the four categories of the Key Risk Assessment Protocol (*no action needed, watching brief, more action needed, immediate action needed*). The evaluation considers current and future risks, the timing of potential impacts, and stakeholder perspectives.

Extreme rainfall, flooding, erosion, and landslides Urgency is rated **More action needed**. These hazards are already present and have caused documented damage, including the 2026 event with losses of about 11 million ALL. As sudden-onset hazards, impacts occur quickly and require preparedness before events take place. Targeted interventions are needed for local roads, drainage systems, erosion-prone areas, and settlements to reduce future damage**.**

Meteorological drought and heat-related water stress Urgency is assessed between **Watching brief and More action needed**. Drought develops gradually, but projections of hotter and drier summers suggest increasing stress on agriculture and water resources. The decline in irrigated area raises concerns about exposure, requiring further stakeholder validation. While direct evidence of damage is limited, the potential for cascading effects—crop yield reduction, ecosystem degradation, and economic stress—justifies closer monitoring and incremental action**.**

Wildfire hazard Urgency is rated **More action needed.** Future projections show fire weather shifting into the Extreme class and the danger index rising sharply. Although local records of wildfire impacts are lacking, preventive measures, landscape management, and emergency planning should be in place before larger losses occur**.**

Stakeholder perspectives Consultations highlighted the distinction between sudden-onset and slow-onset hazards. Vulnerable groups emphasized immediate preparedness for extreme rainfall, while agricultural representatives stressed the importance of water management. Decision-makers acknowledged that flooding requires urgent measures, whereas drought demands a longer-term

strategy balancing monitoring with gradual adaptation.

2.4.5 Understand Resilience Capacity

Resilience capacity in Belsh Municipality has been assessed according to the categories of the Key Risk Assessment Protocol (low, medium, substantial, high). The evaluation considers financial, social, human, physical, and natural dimensions of risk management, alongside existing measures and institutional capacity.

Extreme rainfall, flooding, erosion, and landslides - Capacity is rated Medium. The municipality has experience in emergency response and documented past impacts, showing institutional awareness. However, repeated damage across villages reveals persistent weaknesses in drainage, road protection, erosion control, slope stability, and preventive maintenance. Limited financial resources, uneven preparedness, and the absence of hazard protection plans or insurance schemes constrain resilience.

Meteorological drought and heat-related water stress - Capacity is also rated Medium, though with greater uncertainty. Local agricultural knowledge provides a basis for adaptive practices, but declining irrigated area signals growing vulnerability. Infrastructure for irrigation and water storage is insufficient, and support mechanisms for farmers remain limited. Natural capacity is under pressure, while social and institutional capacity to manage drought risks is not yet robust.

Wildfire hazard - Capacity is provisionally rated Medium, pending further information on local fire-response systems, including equipment, water points, access routes, and records of recent events. Current institutional arrangements and community knowledge provide a foundation, but technical and operational gaps must be addressed.

Cross-cutting observations - Across all three risk pathways, resilience is constrained by gaps in financial resources, technical infrastructure, and institutional preparedness. Stakeholders emphasized the need to strengthen early warning systems, improve drainage and irrigation networks, and expand awareness campaigns to build human and social capacity. Decision-makers acknowledged that while local knowledge and experience exist, structured interventions and external support are required to move resilience capacity from Medium toward Substantial.

2.4.6 Decide on Risk Priority

The process of assigning risk priorities in Belsh Municipality followed the methodology outlined in the Key Risk Assessment Protocol and was supported by the evaluation dashboard. This step integrates the severity, urgency, and resilience capacity assessments to determine which risks require immediate follow-up and which should be monitored for further validation.

Extreme rainfall, local flooding, erosion, and landslide-related impacts -This risk has been assigned **Priority 1**. The decision is based on the strongest local evidence available, including documented past events that caused damage to buildings, roads, agricultural land, olive groves, and local economic assets. The severity of this risk is substantial, the urgency is assessed as “more action needed,” and resilience capacity is medium. Together, these factors indicate that extreme rainfall impacts demand immediate attention in Phase 3, with priority given to preparedness, infrastructure protection, and community resilience.

Meteorological drought and heat-related water stress - This risk has been assigned **Priority 2**. While it is highly relevant for agriculture, vegetation, water resources, and rural livelihoods, the current

evidence on direct impacts is less detailed than for flooding and erosion. Severity is assessed as moderate to substantial, urgency as "watching brief to more action needed," and resilience capacity as medium. This combination suggests that drought and heat stress should remain a priority for further analysis and stakeholder validation in Phase 3, particularly as hotter and drier summers may intensify impacts over time.

Evaluation dashboard summary - The evaluation dashboard consolidates the findings into a structured overview, ensuring transparency and consistency in priority setting.

Table 2-7 Technical key-risk assessment and priority ranking

Risk	*Current severity*	*Future severity*	*Urgency*	*Resilience capacity*	*Priority*	*Basis*
Extreme precipitation and local flood/erosion/landslide impacts	Substantial	Substantial	More action needed	Medium	Priority 1	Strongest documented local impact evidence; large future rainfall intensification
Agricultural drought and heat-related water stress	Moderate	Substantial	More action needed	Medium	Priority 2	Clear future increase in maize ET deficit, yield loss and economic-risk screening

The prioritization of Risks 1 and 2 is consistent with the stakeholder consultation held in May 2026, confirming the shared understanding between technical analysis and community perspectives. **Wildfire** was introduced as a third risk pathway after that consultation. Its ratings—particularly severity, resilience capacity, and overall priority—are therefore provisional and will be reviewed with municipal authorities and stakeholder representatives at the start of Phase 3. This staged validation ensures that the assessment remains participatory, evidence-based, and adaptable to new findings.

2.5 Monitoring and Evaluation

Key lesson from Phase 2: Climate indicators only become useful for decision making when they are directly linked to exposure and vulnerability. By adding future climate projections and completing the hazard and risk steps for drought and wildfire, the overall assessment was made significantly stronger.

Main challenges: The process faced several difficulties, including incomplete local records, mismatched coordinate systems in GIS layers, coarse resolution of climate models, lack of future socio-economic scenarios, absence of a hydraulic flood model, limited geo referenced impact data, and unavailability of daily FWI values. These issues were managed through quality checks, conservative assumptions, keeping the original resolution of datasets, and maintaining a clear distinction between official workflow outputs and supplementary local analyses.

Monitoring system for Phase 3 will track:

- New extreme rainfall and damage events, with precise details on location, affected area, type of asset, road length, crop area, and verified losses.

- Condition of the irrigation network, irrigated area, water availability at sources, and reported shortages in agriculture, updated annually.
- Selected drought indicators and crop yields, to compare modelled water stress with observed field conditions.
- Wildfire incidents, including burnt area, ignition points, response times, affected vegetation and assets, and firefighting resources.
- Changes in land use, buildings, roads, and other exposure layers used in the analysis.
- Implementation and performance of adaptation measures selected in Phase 3**.**

Communication of results will be done through a short municipal risk summary, a full technical report, GIS layers, maps and charts, stakeholder presentations, and publication in the Zenodo repository. Public maps will clearly state their scale and limitations, especially where values in the 100 m grid are derived from coarse climate model cells**.**

2.6 Work plan Phase 3

Phase 3 will build on the current and future risk results to translate evidence into practical adaptation measures. The goal is not to repeat the analysis, but to move from assessment to action.

The main steps are:

1. **Validate risk ratings** – Review severity, urgency, resilience capacity, and priority scores for the three risks with municipal staff, sectoral experts, and community representatives.
2. **Identify priority locations** – Use Phase 2 maps to pinpoint areas most affected: villages with recorded rainfall impacts, vulnerable roads and drainage systems, drought sensitive farmland and irrigation networks, and zones of high wildfire danger.
3. **Develop adaptation options** – Propose measures for each risk and assess them against effectiveness, cost, technical and institutional feasibility, co benefits, environmental safeguards, equity, and maintenance requirements.
4. **Promote multi risk solutions** – Give preference to measures that reduce several risks at once, such as vegetation restoration, soil and water conservation, drainage maintenance, water retention, fire safe landscape management, and climate resilient rural roads.
5. **Define implementation framework** – Assign responsible institutions, indicative budgets and funding sources, timelines, and monitoring indicators.
6. **Integrate into planning** – Ensure selected measures are embedded in municipal development plans, civil protection preparedness, agricultural and water programmes, and the local climate adaptation plan.

Detailed hydraulic flood modelling, parcel level crop loss modelling, and fire spread modelling are outside the scope of Phase 2. These can be commissioned later if specific Phase 3 measures require engineering design or investment appraisal.

3 Conclusions Phase 2- Climate risk assessment

Phase 2 has provided a much stronger evidence base than earlier assessments by combining local observations, detailed GIS exposure data, crop water-balance modelling, wildfire indicators, and future climate projections into a single framework.

Key findings include:

- **Extreme rainfall** already causes documented damage in Belsh and is projected to intensify: +30% for the 10-year event, +38% for the 25-year, +45% for the 50-year, and +52% for the 100-year event.
- **Agricultural drought risk** increases significantly: modelled maize yield loss rises from 5.1% to 16.6%, while the economic indicator grows from about €58,000 to €185,000 per climate-model cell.
- **Wildfire hazard** worsens, with fire weather shifting from *Very High* to *Extreme*, the danger index increasing by about 69%, and the supplementary risk score rising by 45%.
- **Socio-economic conditions** were not modelled; exposure and vulnerability were kept at today's levels to isolate the effect of climate change.
- **100 m maps** were used for overlay and communication purposes, but they do not imply that climate data have 100 m resolution.

Each risk requires a different type of response:

- **Extreme rainfall** → drainage improvement, runoff and erosion control.
- **Drought and heat stress** → water efficiency, irrigation management, and agricultural adaptation.
- **Wildfire** → prevention, landscape management, and preparedness.

The resulting priorities are:

- **Priority 1**: Extreme precipitation and its local impacts.
- **Priority 2**: Agricultural drought and heat-related water stress.
- **Priority 3**: Wildfire (provisional, pending stakeholder review in Phase 3 due to limited local fire data and response information).

Phase 3 will therefore focus on identifying, testing, and implementing adaptation options, using the Phase 2 results as the baseline for evaluating feasibility and monitoring progress.

4 Progress evaluation

Phase 2 of the EVOLVE–Belsh project has achieved significant progress in strengthening the climate risk assessment framework for Belsh Municipality. Compared to Phase 1, the evidence base has been considerably enhanced through the integration of clean climate datasets, detailed GIS exposure layers, crop water-balance modelling, wildfire indicators, and future climate projections. This has allowed risks to be assessed more comprehensively and linked directly to local vulnerabilities.

Stakeholder engagement was expanded, involving municipal staff, civil society, farmers, youth and women's groups, and technical experts. Their input enriched the interpretation of severity, urgency, and resilience capacity, and confirmed the relevance of extreme rainfall and drought as priority risks. The participatory approach also improved ownership and legitimacy, ensuring that results are not only technically sound but also locally trusted.

Despite these advances, several challenges remain. Data gaps persist in socio-economic projections, hydraulic flood modelling, and geo-referenced impact records. Climate models continue

to operate at coarse resolution, and institutional capacity for systematic monitoring is limited. These constraints were managed through quality checks, conservative assumptions, and clear documentation of limitations, but they highlight areas that require further investment in Phase 3.

Overall, Phase 2 has delivered a robust foundation for adaptation planning. It has clarified risk priorities, strengthened institutional awareness, and provided practical tools for communication and decision-making. The next phase will build on this progress by validating risk maps, refining adaptation measures, and embedding them into Belsh's Climate Adaptation Plan, ensuring that resilience strategies are both evidence-based and actionable.

Table 4-1 Technical key-risk assessment and priority ranking

Key performance indicators	*Progress*
3 workflows FLOODS, DROUGHT, and FIRE workflows, enabling a comprehensive multi-risk assessment approach applied	The application of the three workflows, Floods, Drought, and Fire, has enabled Belsh Municipality to move towards a **comprehensive multi-risk assessment**, integrating rapid-onset hazards with slower climate stresses. This progress ensures that risk prioritisation is more balanced and evidence-based, laying the groundwork for coherent adaptation planning across different hazard pathways.
3 local high-resolution datasets integrated in the risk assessment	The integration of three local high-resolution datasets into the risk assessment has strengthened the analysis by providing **more precise spatial detail and locally verified inputs**. This progress ensures that hazard indicators, exposure profiles, and vulnerability mapping are now better tailored to Belsh's territory, enhancing the credibility and usefulness of the multi-risk assessment for municipal planning and adaptation design.
1 consultation workshops with stakeholders	**Consultation Workshop with Stakeholders** demonstrates that the risk assessment process was validated through direct dialogue with local actors. This achievement ensured that findings were reviewed, priorities confirmed, and adaptation options shaped with stakeholder input, strengthening both the credibility and policy relevance of the CRA.

Table 4-2 Overview milestones

Milestones	*Progress*
M4: Local data collection and analysis finished	Local data collection and analysis provided Belsh Municipality with a solid evidence base, transforming fragmented records into structured datasets ready for risk interpretation. This achievement marks a turning point, as the project now moves from data preparation to designing targeted adaptation measures.
M5: Refined risk assessment validated	**Refined Risk Assessment Validated** confirms that the climate risk analysis has been strengthened through stakeholder review and technical validation. This achievement ensures that the priority hazards and risk pathways identified are credible, locally grounded, and ready to guide the design of adaptation measures in the next phase.

5 Supporting documentation

The following supporting materials have been produced or are being prepared during Phase 2. The final outputs should be arranged and uploaded to Zenodo in the same order as listed below.

Table 5-1 . Supporting outputs for Zenodo

Order	*Output group*	*Content*
01	Main report	Deliverable Phase 2 - Climate Risk Assessment for Belsh Municipality (DOCX/PDF)
02	Extreme precipitation	Extreme-precipitation risk outputs: CSV summaries, GPKG, maps, return-level chart, methodology QA
03	Agricultural drought hazard	Drought hazard outputs: NetCDF, CSV, GPKG, ET/yield-loss maps and charts, QA
04	Agricultural drought staple risk	Staple-crop drought risk outputs: CSV, GPKG, current/future risk maps and methodological QA
05	Agricultural drought non-staple support	Tomato analysis (no modelled yield loss with the default crop calendar)
06	Wildfire hazard	Wildfire hazard outputs: seasonal FWI historical/future maps, change map, GPKG and QA
07	Wildfire risk	Wildfire risk outputs: Pareto, danger, exposure/vulnerability and supplementary H x E x V outputs, GPKG and QA
08	Local climate and impact data	Clean meteorological station datasets, local historical event records and agricultural/water-management information

6 References

- CLIMAAX. Climate Risk Assessment Handbook and Framework. https://handbook.climaax.eu/
- CLIMAAX. Agricultural Drought Hazard and Risk Assessment workflows, CLIMAAX Handbook.
- CLIMAAX. 02_wildfire_FWI - FWI Hazard Assessment and FWI Risk Assessment, CLIMAAX Handbook.
- Copernicus Climate Change Service. Climate Data Store; EURO-CORDEX regional climate projections and fire-danger indicators. https://cds.climate.copernicus.eu/
- European Forest Fire Information System (EFFIS). Wildfire exposure and vulnerability indicator datasets. https://effis.jrc.ec.europa.eu/
- MapSPAM. Spatial Production Allocation Model, 2020 V2r2 crop-production data. https://www.mapspam.info/
- FAO / IIASA. Global Agro-Ecological Zones (GAEZ) v5 datasets. https://gaez.fao.org/
- FAO. Crop evapotranspiration and FAO Penman-Monteith methodology; crop-water and yield-response guidance.
- INSTAT. Population and Housing Census 2023, municipal results for Belsh. https://www.instat.gov.al/
- Belsh Municipality. Historical records of extreme events and reported damages, 2016-2026. Local dataset used in this assessment.
- Belsh Municipality. Agricultural and water-management information, including irrigation network, irrigated area and local irrigation water sources.
- Local meteorological station records for Belsh, Cerrik, Grekan, Lushnje, Peqin and supporting precipitation information for Devoll Kozare.
- Digital Elevation Model, PPV land-use layer, building, settlement, road, hydrography and water-body GIS layers used for regionalisation.
- Republic of Albania. Law No. 155/2020 on Climate Change.
- Ministry responsible for environment. National Climate Change Strategy and Action Plan 2019-2030.
- UNDP Albania / Government of Albania. National Adaptation Plan 2026-2036 and sectoral adaptation documents.